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SIR W. E. LOGAN, F.R.S., DIRECTOR.

FIGURES AND DESCRIPTIONS
OF
CANADIAN ORGANIC REMAINS.

DECADE II.

GRAPTOLITES OF THE QUEBEC GROUP.

BY

JAMES HALL.

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MONTREAL: DAWSON BROTHERS.
LONDON, NEW YORK, AND PARIS: BALLIÈRE.
1865.

PREFACE.

The Graptolites of the Quebec group, which are the subject of the present Decade, were first discovered at Point Lévis in 1854, and were then confided for investigation and description to Professor JAMES HALL of Albany, the distinguished Palæontologist of the Geological Survey of the State of New York. This was prior to the appointment of Mr. E. BILLINGS as Palæontologist to the Canadian Survey, in 1856. After a preliminary notice communicated by Professor HALL in 1855, extensive additions were made to the collection of Canadian Graptolites, which were placed in his hands; and in 1858 descriptions by him of nearly all the species here figured were published in the Report of Progress of the Geological Survey of Canada for 1857, but without illustrations. Figures of one of the species were however published in the *Canadian Naturalist* for June 1858; but various accidental difficulties having occurred in the preparation and engraving of the plates, the publication of the Decade has been delayed until the present time.

It is to be remarked that although the name of Decade, under which Parts I, III, and IV were published, is still retained, this monograph is illustrated by not less than twenty-three plates. These are all from excellent drawings by Mr. R. P. WHITFIELD of Albany. Twenty-one of them were engraved on steel by Mr. JAMES DUTHIE of New York, and the remaining two were lithographed by Mr. F. J. SWINTON of Albany.

W. E. LOGAN.

GEOLOGICAL SURVEY OFFICE,
Montreal, December 1864.

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ERRATA.

Page 146, 6th line from bottom, and page 147, 4th line from bottom, for Reteograptus read Retiograptus.

Page 147, second line from bottom, read "The frond *four* times enlarged."

GRAPTOLITES OF THE QUEBEC GROUP.

CHAPTER I.

INTRODUCTION.

§ I.—NATURE AND FORM OF GRAPTOLITES.

Until recently the graptolites were, with two or three exceptions, known only as simple, straight, or slightly curving linear stipes or stems, usually lying in the same plane upon the slaty laminæ in which they were imbedded. Nearly all these were evidently fragmentary, and, though varying somewhat in their proportions, rarely exhibited anything that could be regarded as the commencement or termination of their growth or development. These bodies, in their flattened condition, present a range of serratures either on one or on both sides of the stipe; and seldom preserve more of their substance than a carbonaceous or corneous film or test of extreme tenuity. Under more favorable circumstances, these serratures are discovered to indicate the apertures of cellules, symmetrically arranged in reference to each other, and to the axis of the linear stipe. Others show parallel entire margins, with transverse indentations across the central portion of the stipe. This appearance we now know to be due to the direction of the pressure upon the body exerted at right angles to the cellules, and which will be explained in the sequel.

The earliest opinion regarding these fossils was that they were of vegetable origin; and they have been thus considered by some authors even at a very late period. Subsequently, they were referred by Wahlenberg, and after him by Schlotheim, to the Cephalopoda, being regarded as extremely slender orthoceratites. This opinion may have received support from specimens in such condition as *G. scalaris*, where the indentations are limited on each side by a continuous margin; but in such as present a single or double series of marginal serratures, the analogy seems very remote. Professors Geinitz and Quenstedt advocated the same view at a much later date; though it has since been abandoned by these authors, from more extended investigations.

Professor Nilsson first suggested that graptolites were Polypiaria, belonging to the family Ceratophyta. Dr. Beck of Copenhagen regarded them as belonging to the group Pennatulidæ, of which the Linnean *Virgularia* is the most nearly allied existing form. Sir Roderick Murchison has adopted this view of the relations of the graptolites, in his Silurian System.* General Portlock has fully recognized the graptolites as zoophytes, and has pointed out their analogy with *Sertularia* and *Plumularia.*

The relations of graptolites with the Cephalopoda had already been fully disproved by M. Barrande (in the first chapter of his "*Graptolites de Bohème*"), before the abundant materials for the refutation were discovered in the graptolites of the Quebec group; and most naturalists were already agreed in referring these bodies to the class of Polypi, to which they doubtless belong.

More recently, Mr. McCrady, of South Carolina, has published a paper on the "Zoological Affinities of Graptolites,"† in which he has endeavored to show the similarity of the graptolitic forms with the Echinoderm larvæ, as illustrated by Müller. There is certainly much resemblance between the enlarged figures of that author, and some forms of graptolites in the shales of the Hudson River valley; while some of the figures with central discs have a more remote analogy with certain forms from the Quebec group. Some of the toothed rods of the Echinoderm larvæ likewise bear a resemblance to the graptolites figured by Mr. Suess;‡ and there are still farther analogies pointed out by Mr. McCrady, which, however, may not be regarded as of equal value by the greater number of naturalists.

For my own part, although admitting the similarity of form and of some of the characteristics which were very kindly pointed out to me by Mr. McCrady, long before his publication, I cannot recognize the analogy sought to be demonstrated. The establishment of the fact that these toothlets or serratures are the extensions of true cellules, each one having an independent aperture, and communicating with a common canal, should offer convincing argument against these bodies being other than polyp-bearing skeletons. But, in following the extensive series of forms now presented to us, we have much evidence to show that some of these were attached to the bed of the ocean, or to other bodies; while the greater proportion of the species and genera appear to have never been attached to the sea-bottom.

It may not be easy to determine precisely the family to which these graptolitic forms should be referred; nor is it certain that the extensive series now presented can all properly be referred to a single family. General Portlock has suggested that these bodies may constitute "several genera belonging even to more than one order."* That they are true Polypi, I believe we shall be able to show, both from analogies already established by various authors, and also from their mode of development or reproduction as exhibited in some of the species.

---

* Silurian System, page 694; and letter of Dr. Beck, pp. 695-6.

† "Remarks on the Zoological Affinities of the Graptolites, by John McCrady, made before the Eliot Society of Natural History of Charleston, S. C., at the meeting of July 15, 1857." [Extract from the Proceedings, vol. i.]

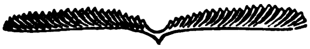
‡ Naturwissenschaftliche Abhandlungen. Vierter Band. Tab. viii and ix.

The specimens which have usually been observed or represented are simple disconnected stipes, doubtless the dismembered or fragmentary portions of fronds, which, presenting in the different species great varieties of form and aspect when entire, are nevertheless composed of parts so similar that these fragments, though indicating specific differences, offer little clue to a knowledge of the entire form.

The name *Graptolithus* was established by Linnæus in the first edition of his "*Systema Naturæ*," 1736, and applied by him to the straight or curved forms which are serrated (celluliferous) upon one side only, of which *G. sagittarius* has been regarded as the type.† The propriety of this term is more readily perceived in its application to the fragments of the stipes of monoprionidian forms than to the central portions of the body of the same. In the spirally-enrolled forms, or those with four or more stipes uniting in a central disc, as well as in the variously-branching forms, the analogy is not so perceptible.

Taking those species which, in the form of their cellules and in the separated fragments of the frond, would be referred to *Graptolites* proper, and tracing them, as we are now able to do in many species, to their perfect condition, we find a great variety of form and mode of growth. In the simplest of these we have two stipes diverging from a radicle, or initial point; and the parts remain so complete as to admit of no doubt that this is the entire skeleton of the animal. The cellules near the base of the stipe are not so fully developed; while also those near the extremities have not reached their full dimensions, and the last one is sometimes barely perceptible, or just assuming its form from the common body. These characteristics are perceptible in the figures upon plates i, ii, and iii.

Fig. 1.



GRAPTOLITHUS PENNATULUS.

In the next stage we have four simple stipes diverging from an initial point, and all evidently entire, as shown in the development of the cellules.

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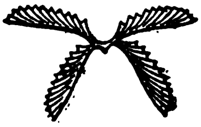
* Geological Report on Londonderry, &c., p. 318.

† I shall elsewhere endeavor to show that *G. scalaris* is a diprionidian form exhibiting only one margin.

Fig. 2.



Graptolithus bryonoides.

In some species of this mode of growth, the bases of the stipes are united in a more or less expanded disc or cup of the same substance as the body of the graptolite. The form of this disc is shown on plates v, vi, vii, viii, and ix, and also in the accompanying figure of *Graptolithus Headi*.

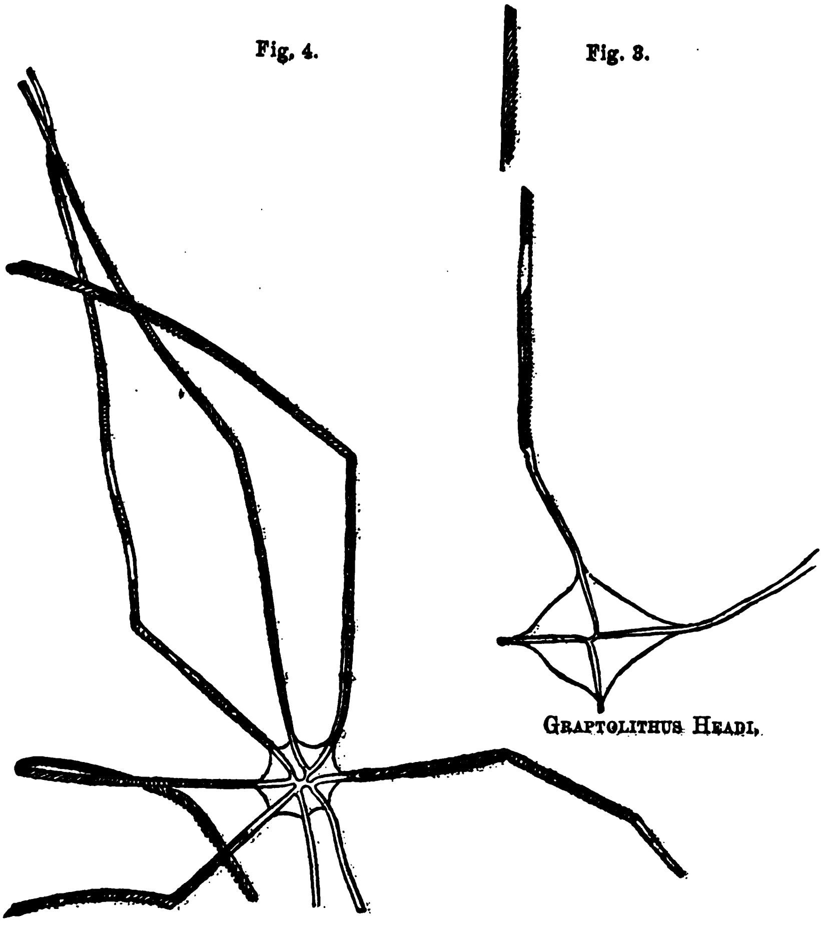


Fig. 3.

Graptolithus Headi.

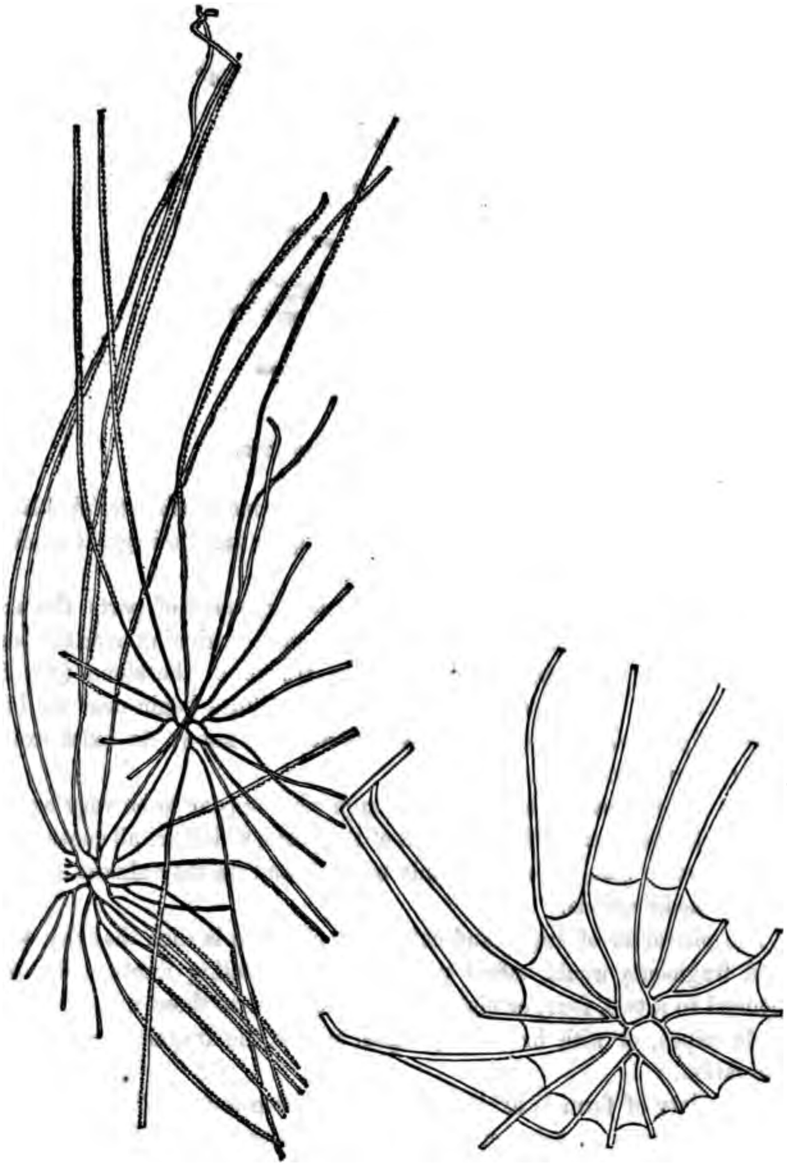
Fig. 4.

Graptolithus octobrachiatus.

In a farther development in the same direction, we have fronds with eight simple stipes, which may or may not be united in a central disc, as in the accompanying figure.

In *Graptolithus Logani* we have numerous simple stipes united in a central disc or cup; while in some specimens otherwise precisely similar, we have no remains of the disc. In all these species the parts are disposed in a symmetrical and bilateral arrangement.

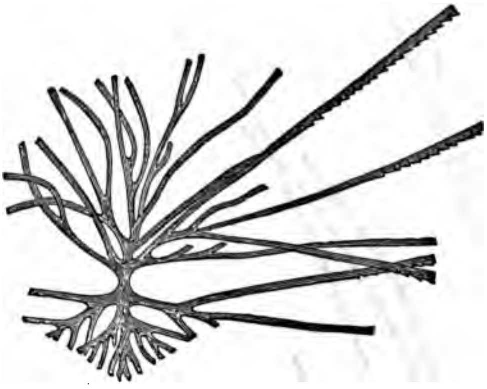
Figs. 5 and 6.



GRAPTOLITHUS LOGANI.

The stipes of this species do not bifurcate beyond the disc, and there are no cellules below the last bifurcation. The number of stipes in different individuals varies from sixteen to twenty-five, so that this character cannot be made of specific importance. In another similar species without a central disc, from the Hudson River formation, we have above forty stipes, which do not bifurcate, so far as known, beyond the commencement of the cellules.

Fig. 7.



GRAPTOLITHUS MULTIFASCIATUS.

The separated and broken stipes referred by me to *Graptolithus sagittarius* * are probably of this species, occurring as they do in great numbers in the same beds in which this was found.

In other species with a similar general arrangement of parts, the main stipes are frequently bifurcated; the bifurcations beginning near the base, and continuing as far as the parts can be traced in the stone (fig. 8). In some of the species of this character the cellules begin near the base of the stipes, while in one species they are not known to exist except on the outer branchlets.

Thus far we trace these forms through what appear to be very natural stages in the progress of development of the parts, which are all constructed upon the same plan, presenting only natural, and we may almost say consequent modifications.

The character of stipes and cellules in all these is such that the separated fragments would afford no means of indicating whether the part belonged to a two, four, or eight-stiped species, or to those with numerous simple stipes, or with branching stipes, unless the fragment retained a bifurcation.

A variety of form is exhibited in the division termed *Dendrograptus*, in which we may conceive of the numerous stipes near the base becoming

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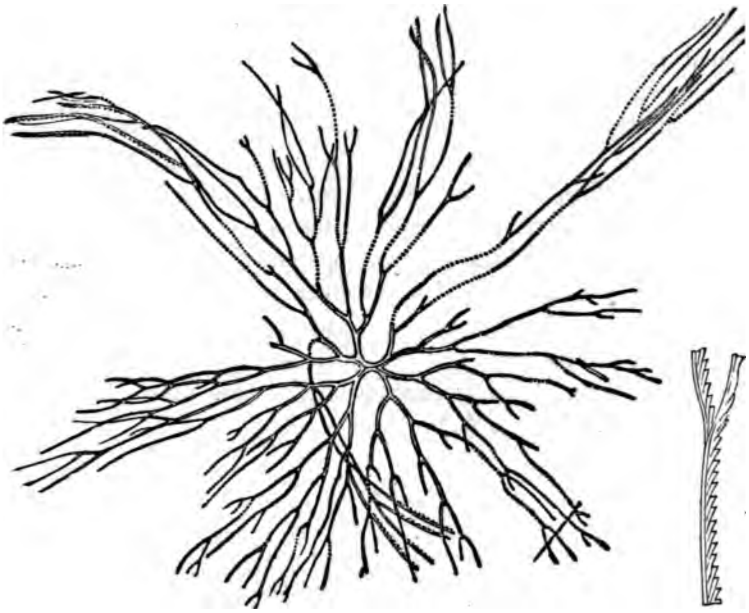
* Palæontology of New York, vol. i, page 272, pl. 74, fig. 1.

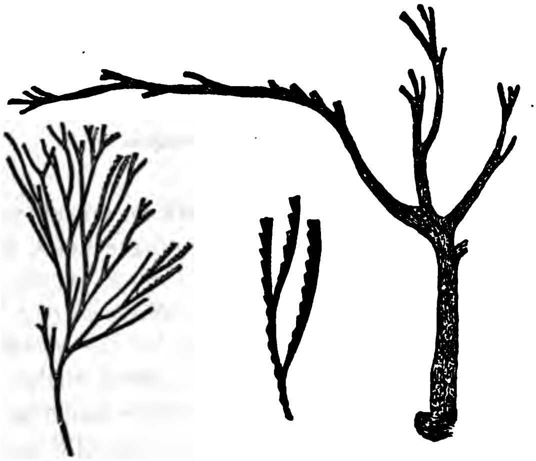
Fig. 8.



Graptolithus flexilis:
with a portion enlarged.

conjoined into one strong stem, with the bifurcating branchlets spreading above, and this stem probably fixed in the soil. We then have a representation of the typical forms of this genus, as in the accompanying figure, and as illustrated on plate xvii, figs. 8 and 9, of this memoir.

Fig. 9.

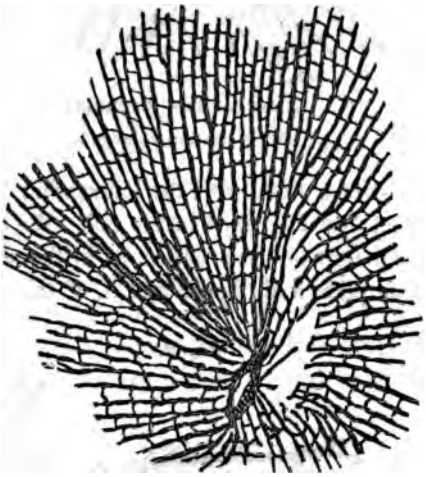


Dendrograptus Hallianus.

In this species, as shown in the enlargements of the branchlets, we have a form of cellule similar to that in observed fragments of the ordinary species of graptolites. The cellules are very minute, and, from the frequent ramifications, this would probably always be recognized as a branching species.

Some of the forms of *Dendrograptus* have slender spreading branches, and less rigid stems than the typical species, but still retain the angular cellules, as in figs. 1 and 2 of plate xvii. From these we pass almost imperceptibly to the slender spreading forms which I have termed *Callograptus*, plate xix, in which there is, apparently, some slight modification in the form of the cellule; and on the other hand, there is an almost insensible gradation to the *Dictyonema*, plate xx, in which the branches are connected by lateral bars, and the whole developed in a flabelliform or funnel-shaped frond, with angular cellules on the inner margins of the branches. (Fig. 10, plate A.)

Fig. 10.

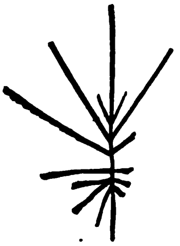


DICTYONEMA RETIFORMIS.

There are certain forms of graptolites, which, though possessing linear straight or slightly curving stipes and angular cellules, like the typical species, have yet a different aspect, and do not so naturally fall into the series. Among these we find *Graptolithus divergens* (fig. 11), where the bilateral relation of the parts is still shown, but the celluliferous stipes or branches are arranged on the two sides of a slender stipe or rachis, and diverge on each side from what appears to be the centre or initial point.

Different specimens show some slight variations of these characters, but not any essential differences.

Fig. 11.



GRAPTOLITHUS DIVERGENS.

Another form, which we know only in small individuals, is illustrated in the following figures, which remind one of some forms of the recent genus *Crisia.*

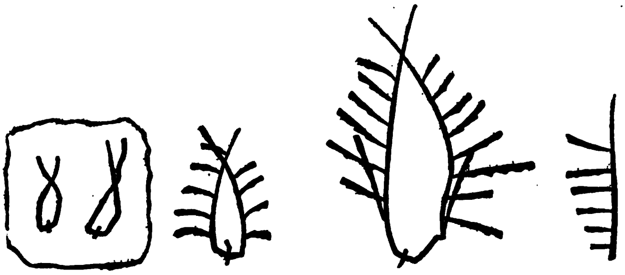
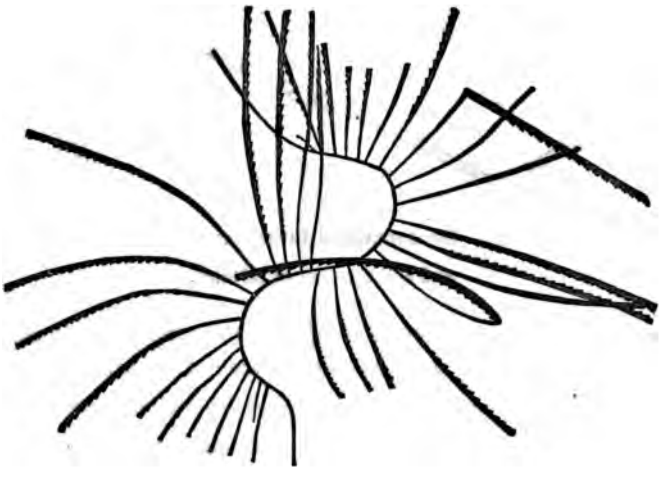


Fig. 12. Fig. 13. Fig. 14. Fig. 15.

(These figures are enlarged to twice their natural size.)

In another form with similar angular cellules, we have the following illustrations of the mode of occurrence of the species.

Fig. 16.



GRAPTOLITHUS GRACILIS.

Fig. 17.

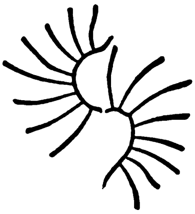
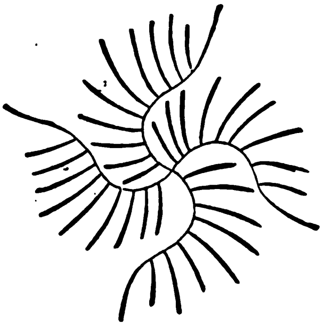


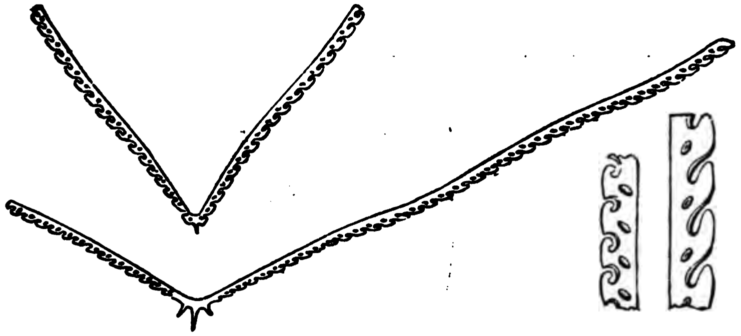
Fig. 18.



GRAPTOLITHUS GRACILIS.*

We have still another group, presenting some differences, more particularly in the development and form of cellules, than in their general form; and seeming in some species to unite the characters of those having a single range, with those having a double range of cellules. The simpler forms of this type are similar to the two-stiped forms of the first series; but in all those, whether of two, four, or more stipes, the cellules are developed on the upper side, or that side opposite to the initial point. In species like *G. sextans*, *G. divaricatus*, and others of this type, the cellules are on the lower, or same side with the radicle.

Fig. 19.



GRAPTOLITHUS DIVARICATUS:

and enlargement of cellules.

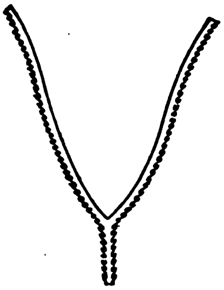
In the accompanying figure of *G. divaricatus*, the frond consists of two simple uniserrate stipes; and the same is true of *G. sextans*, except that it is united at the base for the length of a single cellule. In *G. furcatus* the stipes are conjoined for a distance of two or three cellules above the base.

---

* The fig. 18 was theoretically constructed, but has since been verified by the discovery of a specimen having the same form and arrangement of parts.

In *G. ramosus*, as shown in the following figure, the lower part of the stipe, for a considerable distance, has a range of cellules on each side, parallel with the axis; and becoming bifurcate above, it presents two stipes or branches, each with a single range of cellules. All the species of this group have a peculiarity in the form of the cellules, which will be noticed hereafter.

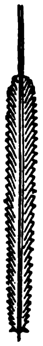
Fig. 20.



Graptolithus ramosus.

These species, in their mode of growth alone, present forms which might be regarded as intermediate between the monoprionidian and diprionidian groups; though the typical forms, *G. pristis* and allied species, never show any tendency to a division of the parts of the stipe; and we shall observe, as we progress, that these forms are connected with other differences of structure.

Fig. 21.



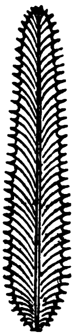
Graptolithus pristis.

The species of this type (*Diprion* or *Diplograptus*) are simple linear or sub-linear stipes, bearing a range of cellules on each side, often showing an initial point or radicle at the base, and an extension of the slender axis above and beyond the celluliferous portion.

From these forms with a double series of cellules, we pass to the broad foliiform stipes, which are apparently composed of four semi-elliptical parts conjoined along their straight sides, and thus present four ranges of cellules. These forms (*Phyllograptus*) are, in some species, broad and short, while others are elongate, with sub-parallel sides, as shown in the accompanying figures.

[See also plates xv and xvi.]

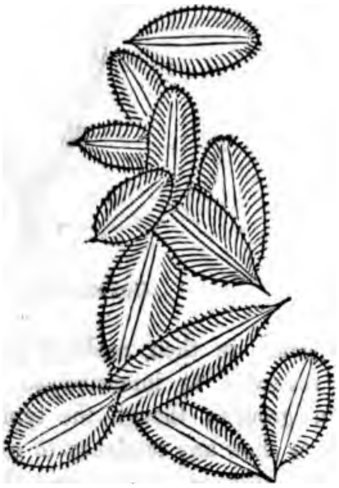
Fig. 22.



Phyllograptus augustifolius.

(See illustrations under generic description, and plates xv and xvi.)

Fig. 23.



Phyllograptus typus : a group of separated stipes as they lie upon the surface of the shale.

From the occurrence of a large number of these leaf-like stipes, sometimes crowded together in a small space, I have inferred that they may have grown as *Retiograptus*. (Plate xiv, fig. 9.)

Following the forms with a double series of cellules, are those of similar general form, the *Retiolites*, which are known only as simple stipes. (Plate xiv, figs. 1–5.)

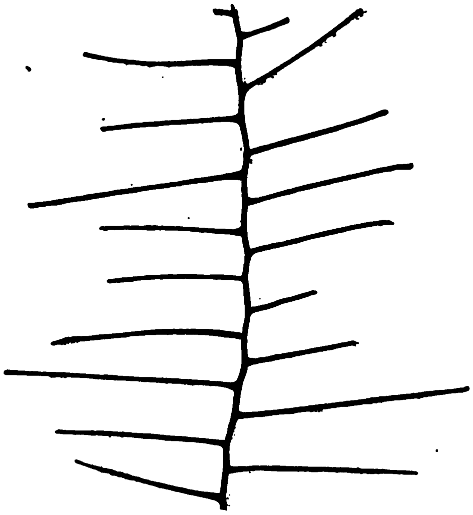
In the *Retiograptus* we have simple elongate stipes; and in one form (plate xiv, fig. 9) we have the stipes united by slender basal extensions in a spreading frond, in a manner not unlike some of the graptolites proper, with the parts in bilateral arrangement.

In the genus *Rastrites* of Barrande we find a departure from all of the preceding forms in the slender stipes with delicate slender tubular cellules.[*] The species of this genus, so far as known, have the cellules developed on one side only of the stipes or branches; though there seems no reason why we should not have species with cellules upon the two sides of the axis.

The species for which I have proposed the name *Thamnograptus* consist of slender cylindrical stipes and branches, some of them very similar in general aspect to *Rastrites*, but the alternating branches are long and slender, and we have found no appearance of cellules on any part of the specimens known.

In the accompanying illustration the branchlets are given off alternately on the opposite sides of a stipe or rachis, and the slender solid axis can be traced from the main stipe into and along the centre of the branchlets. The analogy between these forms and the celluliferous graptolites of the preceding illustrations does not appear to be very intimate, but they occur in the same beds, and the fossil has the same texture and substance.

Fig. 24.



THAMNOGRAPTUS TYPUS.

In the genus *Ptilograptus* (plate xxi) we have a somewhat analogous mode of growth, but there is always an aspect or expression of the fossil which distinguishes it from *Thamnograptus*. In one species of *Ptilograptus* moreover, cell-apertures have been detected on one side of the branches or pinnulæ.

In the *Buthograptus* we have a form bearing some analogies with the preceding, but the rachis is flexible, and is not known to be branched, while the slender alternating pinnulæ are flat and simple, as they have been observed in numerous individuals. The specimen represented is even less curved than the usual condition of this species in the slaty Trenton limestone of Wisconsin.

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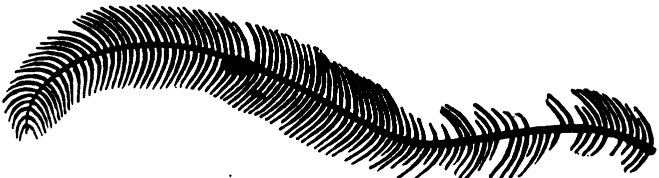
[*] See illustration of *Rastrites Barrandi* under section iii, p. 26, of this introduction.

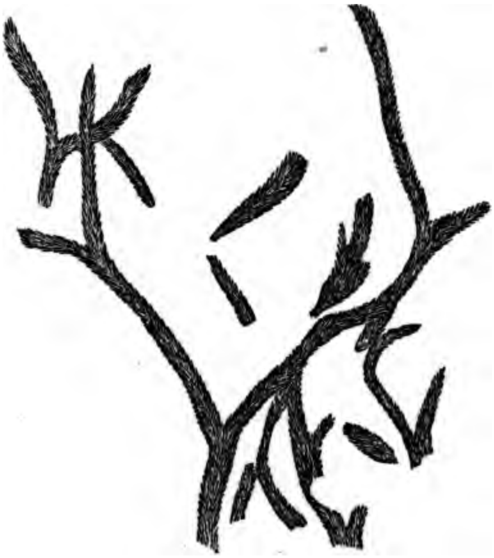
Fig. 25.



BUTHOGRAPTUS LAXUS: enlarged.

Still more obscure, and perhaps remote in its analogies with graptolites, is the genus *Inocaulis*, consisting of flattened scabrous stems, associated with *Dictyonema* in the shale of the Niagara formation, which, from their carbonaceous substance and apparent graptolitic texture, I have referred to the Graptolitidæ.

Fig. 26.



INOCAULIS PLUMULOSA.

§ II.—THE CENTRAL OR BASAL PORTIONS OF THE GRAPTOLITE.

1. The radicle, or initial point.
2. The funicle, or non-celluliferous connecting portions of the stipe.
3. The central disc.

1. *The Radicle, or Initial Point.*—In the most simple forms, or those with two stipes, as shown in all the figures on plate i, there is a slender initial process, which I have termed the radicle. This presents a greater or less development in the different species; in some being reduced to a mere pustule, or scarcely perceptible point, while in others it attains a quarter of an inch or more in length. Although in none of the species with a single range of cellules does this part show absolute evidence of having been attached to any other substance at the maturity of the fronds, yet it is possible that in the earlier period of its growth, the body may have been temporarily attached at this point to the sea-bottom or to some object; though all the evidence is opposed to this view.

In some of the bi-celluliferous forms, and probably in all of them, there is a somewhat similar extension below the base of the celluliferous portion of the stipe, though it is usually more slender; but whether this is always the true initial point of the whole body, or whether it is only the broken point of attachment to a frond, may sometimes admit of doubt. It is conspicuous in *Phyllograptus typus;* and we observe this feature also in *Retiograptus;* but in one species of this we learn that it is only a broken process of attachment of the individual stipe, which existed as one of the members of the entire frond, the true initial point of which would be in the centre of the whole. (Pl. xiv, fig. 9.)

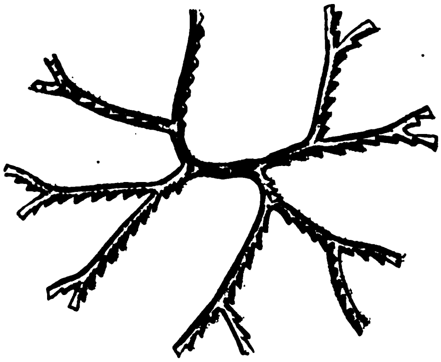
In all the forms of Graptolitidæ which appear to have been free, the initial point or radicle is in fact the commencement of the *solid axis*, which will be noticed farther on. In those graptolites with two simple stipes, the little radicle-like process enlarges above, and the stipes, diverging in opposite directions, are closely united at their bases, and the cellules begin almost in the axil between the two. (Plate i, figs. 1, 3, 7, 9, and 10.)

2. *The Funicle.*—In the graptolites with four stipes, the condition appears like that of two individuals of the two-stiped forms, conjoined by a straight connecting process of greater or less extent, with the radicle point in the centre, though often obscurely marked. This connecting process is *always destitute of cellules;* and this, with its divisions, I have termed the funicle.

In those forms with eight stipes the funicle is twice divided at its two extremities; and where there is a greater number of simple stipes, it is correspondingly subdivided. Neither the central portion, nor any of its subdivisions, becomes celluliferous; and these parts are not termed stipes or branches, according to the views I have entertained. It is only beyond the last subdivisions of this part of the body, as in *G. Logani*, that the celluliferous parts, or the true stipes, commence.

In one of the proper branching forms, however, the cellules begin immediately beyond the first subdivisions of the funicle, as in the four-stiped species. (Fig. 27.)

Fig. 27.



GRAPTOLITHUS MILESI.

These barren, or non-celluliferous portions of the graptolitic body, are not otherwise essentially different from other parts of the stipe. In the absence of cellules they are consequently more cylindrical, and apparently more solid, as if the test were thicker, and the common canal less developed than in the other parts of its extent.

3. *The Central Disc.*—In several of the species having four simple stipes, in one species with eight, and in another with a larger number of simple stipes proceeding from a common centre, we find their bases united by a thickened corneous expansion of the same substance as the body of the graptolite. This appears to be composed of two laminæ, which, at least in the central portions, are not conjoined, and the space is probably occupied by some softer portion of the animal body. (Plates v–ix.)

The substance of the disc sometimes extends along the margins of the stipes, producing an alation, as in *G. alatus.* (Pl. vi, fig. 9.)

This arrangement of the parts of the body seems obviously adapted to give strength and support to the bases of the stipes; but beyond this it probably serves other purposes of the animal economy. In several specimens of *G. bicornis* there is a disc or bulb at the base of the stipe, which, spreading between the two oblique curving processes, envelopes, in the compressed condition of the specimens, some of the celluliferous part of the stipe at its base. In other specimens we have a crescent-shaped extension, as if the disc were in process of development, or perhaps of absorption. Much the larger proportion of the specimens of this species, however, are destitute of disc or bulb, and have every appearance of being complete without this appendage.

These aspects of the species are shown on plate A, figs. 13, 15, 16, and 17.

How far the bulb-like appearance at the base of some of the species of *Dendrograptus* may correspond to the disc of *G. bicornis*, I have not at this time the means of satisfactory determination.

§ III.—THE NATURE AND PARTS OF THE STIPE PROPER.

1. The solid axis.
2. The common canal.
3. The calycles or cellules.
4. Nature and ornaments of the test.

1. *The Solid Axis.*—All the graptolites proper have been found to be provided with a slender solid axis,[*] while this feature has not been satisfactorily proved in regard to *Dictyonema*, and to some other forms.

In those species having a single series of cellules, this axis is upon the back of the stipe, or on the side opposite to the celluliferous margin; and in the branching forms it follows all the ramifications. In all the specimens where it has been observed, it is a slender cylindrical or flattened filiform solid body. In some extremely compressed specimens, this axis appears as a slender elevated ridge along the back of the stipe; and where the substance of the body has been removed, it leaves a narrow groove along the margin of the impression.

In the examination of large numbers of specimens of the monoprionidian species, we have never found the axis prolonged beyond, or denuded of, the cellules; as shown in *G. colonus*, by Barrande, in his Graptolites of Bohemia. (Plate ii, fig. 5, of that memoir.)

In all the specimens where the extremities of the stipes are entire, as represented in plates i, ii, and iii of this memoir, there is never any extension of the axis beyond the last partially developed cellule; and the number of specimens in this condition is considerable.

In the graptolites with two series of cellules, the solid axis is very frequently seen extending beyond the celluliferous portion of the stipe at its outer extremity; while the radicle appears like the continuation of the same below the base. The axis thus appears to be the foundation on which the other parts are erected. In those specimens, however, which present so great an extension of the solid axis beyond the stipe, the cellules may have been removed by subsequent causes.

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[*] In those species with a single series of cellules, M. Barrande has ascertained that this axis is solid and cylindrical, its diameter not exceeding ¼ millimetre, and its structure apparently fibrous. (*Graptolites de Bôhème*, page 4.)

I am able to corroborate to some extent the observations of M. Barrande in regard to the apparent double character of this axis. In some extremely compressed specimens it is marked by a longitudinal groove or line of division;* while in others, a double impression has been left by the removal of the substance.

In some specimens, particularly the younger ones, the solid axis has been seen extending beyond the base of the stipe, as a duplicate process, exhibiting a character as of a double radicle. In some solid specimens of one species, where the tube had been filled with calcareous mud, I am able to detect only a single round point; and a longitudinal section of the same species presents a slender filiform axis. It may be, however, that the parts are so minute and so closely united, as to render them undistinguishable.

In another species, with two rows of cellules, and in which the latter are of very different form from the preceding, the solid axis is a thin flat apparently double plate, extending across the entire transverse diameter of the tube, which is more than two-thirds as great as its longer diameter. The place of the axis is marked by a longitudinal groove on each side, not in a direct line, but slightly undulating to correspond with the cellules. M. Barrande conceives that the joining of the two plates of this axis may leave a very flat intermediate tube; and in our specimen, there is apparently an extremely narrow space between the two. He farther supposes that each of these plates, composing the double axis, is separable, by decomposition, into two laminæ, as illustrated in plate iii, fig. 3, of the work already cited.

The entire appearance of the species (plate A, fig. 10) is that of two monoprionidian stipes joined together at the back, the line of junction being indicated by the groove.

In one species of *Retiolites* there is a strong excentric or sub-exterior axis, which is nearly direct; and in the same individual there is another undulating axis, to which the cell-divisions of one side are attached. In the *Retiolites* of the Quebec group, one side of the stipe shows a very distinct axis, while upon the other side it is very obscure.

In *Retiograptus* we have a very distinct central axis projecting below the celluliferous portion of the stipe, and, in one species, uniting in a funicle, and forming part of a compound form. In another species, the simple stipes present similar features, showing at one extremity the duplicate character of the axis.

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* The aspect presented by the axis, when marked by a longitudinal groove, is precisely that which a hollow cylindrical body would have if extremely compressed.

In *Phyllograptus*, the central axis is apparently composed of four slender flat laminæ; but we have had no means of examining this part of the body in a satisfactory manner.

2. *The Common Canal.*—In all graptolites with a single series of cellules, there is, between the bases of these cellules proper and the solid axis on the back of the stipe, a continuous sub-cylindrical space or canal, which has been occupied by the body of the polyp, from which the buds, with their calycles forming the cellules, take their origin, and are thrown off at regular intervals.

All the specimens which I have examined confirm this view; and in some of the species where the extremities are apparently entire, we observe the incipient development of the young cell from the common body. In those specimens filled or partially filled with the substance of the surrounding rock, this canal is easily distinguished; while in compressed specimens there is always a flattened space between the bases of the cell-partitions and the solid axis.

In those graptolites with two ranges of cellules, we have apparently a duplication of those with the single series, the two solid axes being joined together, leaving a common canal or body on each side at the base of each series of cellules. If however the common body were thus divided, it would be by the solid axis becoming a flattened plate. This appears to be true of some species (as for example, plate A, fig. 10), while in others there is only a simple filiform axis visible. In this case, of course, there is not an entire division in the common canal after the manner of the other species. This will appear farther on, under the illustrations of the structure of these bodies.

In *Retiolites*, the common body occupies the central portion of the stipe, giving origin to a series of buds on each side, while it is not divided by a central axis.

In some species the common body seems likewise to have more extensive functions; for in such forms as *G. divergens* and *G. gracilis*, there is a long slender rachis, or tubular body, destitute of cellules except at its two extremities, and apparently consisting of a solid axis and a common canal, from which originate, at regular intervals, simple small stipes with solid axis, common canal, and cellules.

This appears to be one step farther in our knowledge of the origin or mode of development; but it shows that a stipe or main axis may produce in one part celluliferous stipes, and in its extremities develop only cellules, as we see in the continuation of the main axis of *G. gracilis* and

G. divergens, where the continuation of this common rachis is marked by marginal cellules of the same character as those of the lateral stipes.

The common body therefore appears to perform the double function of developing the buds which elongate into stipes with cellules, and also of simple cellules; or we may consider the celluliferous extremity of the rachis, or main axis, as the termination of the reproductive process, or as analogous to one of the lateral celluliferous stipes. In the Sertularians we have something analogous to this mode of development. Some of the species have cellules along the common or main trunk, and produce at intervals branches or branchlets in place of cellules; others have a common body, or main stem, entirely destitute of cellules, but producing branches on each side (opposite or alternate, as the case may be), which branches produce cellules only.

So long as this rachis gives off only celluliferous stipes, it is analogous to those parts of the simple graptolites which I have termed the funicle, having within itself the sources of this development of the several parts. The mode of development differs from that of the branching forms, inasmuch as the branches proper arise from a division of a cell-bearing stipe or branch, and of course a division of the solid axis and common body.

In *Retiograptus*, some specimens show the cell-divisions reaching nearly to the axis, leaving room on each side for a narrow common body or canal; while in a species from the Utica slate, which presents one side of an entire frond, the cell-divisions of the exterior side all reach to the axis, leaving the common body on the inner or upper side. In a species from Norman's Kill, near Albany, there are three parallel ranges of reticulations, with apparently two filiform solid axes, forming the divisions between the three meshes. This structure probably occupies one side of the stipe, while the common body may occupy the other side.

In *Phyllograptus*, the cell-partitions reach very far towards the centre, and the space left for the common canal is very small. We infer from the better-preserved specimens that there is a slender common canal at the base of each range of cellules. These several canals may or may not communicate with each other.

3. *The Calycles or Cellules: their form and mode of development.*—Since a large proportion of the specimens of graptolites which come under our observation for the purposes of study or otherwise, are fragmentary, it becomes of much importance to know the general characters of form and mode of development of the cellules.

In the preceding section it has been shown that the cellules, or the inhabitants of these cellules, are not independent, but all have their origin in a common body, which fills the longitudinal canal, and that they remain in constant connection with the same throughout their existence.

The calycle or cellule is formed by budding from one side of the common body, not unlike many of the Sertularians, except that the cellules are generally close together at their origin.* They are usually more or less oblique to the direction of the axis, as is clearly indicated by the cell-partitions; and the degree of obliquity often indicates specific distinction. The cellules are for the most part contiguous at their origin, and they sometimes remain in contact throughout their entire length; but in the greater number of species there is a small portion of each one free on one side towards the aperture. This character is shown in numerous examples. (Plates i, ii, and iii.)

In some forms the cellules are contiguous in their lower portions, while the entire upper or outer part becomes free, as seen in *G. Clintonensis* (plate B, figs. 1, 2, and 3); while in one of the bi-celluliferous species from Iowa, the cellules are distant from each other at their origin, and the upper extremity of one scarcely reaches to the base of the next in advance (plate A, fig. 10); and they are therefore not properly in contact in any part of their length. The same is more emphatically true of *Rastrites*, (fig. 27), where there is a large interval between the bases of the cellules, which are often nearly rectangular to the axis.

Although we regard the cellule as limited by the cell-partitions, yet in well-preserved specimens there is sometimes a swelling of the test of the common body below the cellule, indicating an enlargement of the parts at the bases of the buds. In one species there is an evident undulation of the axis, corresponding to this enlargement of the parts in the common body. (Figs. 10 and 11, plate A.)

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* The mode of budding and the form and arrangement of the cellules in the Sertularians are shown in the accompanying figures of two species of *Sertularia* (figs. 1 and 2) from our own coast. Fig. 3, with a range of cellules on one side only, is a *Plumularia.*

Fig. 1.

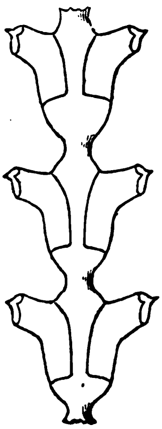


Fig. 3.

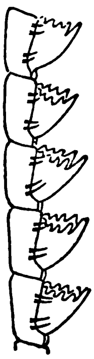


Fig. 2.

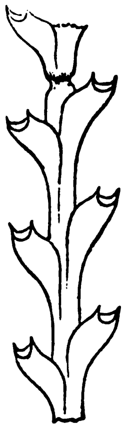
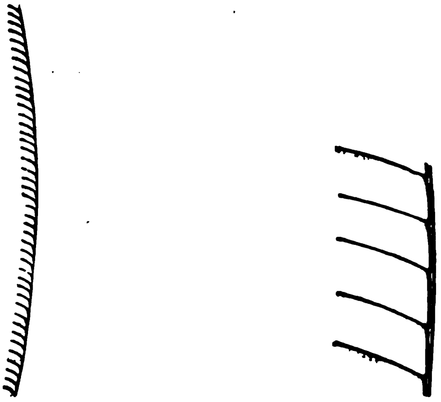


Fig. 28.



RASTRITES BARRANDI:

natural size, with a portion enlarged. The cellules consist of long slender tubes.

In the diprionidian species, the cellules on the two sides of the stipe are alternating, so that the bases or the apertures are opposite the space between two others. This is more especially shown in the enlarged figures 10 and 12, plate A.

In much the larger proportion of species, the body of the graptolite and the cellules are so extremely compressed, that they appear only as serratures along the margin, with distinct impressed lines marking the cell-divisions. The exterior margin of these serratures indicates in an approximate degree the outline of the aperture; and the frequently occurring mucronate extension at the extremity of the cellule is produced by the continuation of the cell-partition, or sometimes by an outgrowth from the margin of the stipe above or below the aperture.

Were the cellules isolated, their prevailing form would be that of an elliptical tube or sac, the length of which is greater than either of the two diameters. When they are in juxtaposition, however, the contiguous sides are flattened, while the lateral or external surfaces are usually more or less curved, particularly near the aperture. In a larger proportion of the species, the calycle becomes slightly expanded towards the aperture; but in a few examples there is a distinct contraction above the middle, and the aperture is smaller than the base. Generally, however, the smaller diameter is just at the junction with the common body, or at the junction of the cell-walls with the walls of the common canal.

In a single diprionidian species, where the specimens are not distorted by pressure, a longitudinal section of the stipe in the direction of its greatest diameter (plate A, fig. 12), shows the cellules scarcely narrowed at their origin with the common body; while in a lateral view of the specimen, the base of the cellule is seen to be much wider than the orifice. (Plate A, fig. 10.)

In many of the species a transverse section of the cellule near the base is quadrangular, becoming more rounded towards the aperture; and when the upper part of the cellule is free, the aperture is round or elliptical, and in some specimens the calycle is elliptical or cylindrical throughout its entire length. We have examples of the quadrangular cellules in *G. extensus* (plate ii, fig. 16) and *G. octobrachiatus* (plate vii, figs. 5 and 7); as well as in two species of *Phyllograptus* (plates xv and xvi). Where the cellules are more nearly isolated, they approach more and more to the cylindrical form. As examples of cellules contracted towards the aperture, we have *Graptolithus priodon*, Barrande, and *G. Clintonensis*, Hall. (Plate B, figs. 1, 2, and 3.)

M. Barrande has remarked that from the circumstance of the partial or complete isolation of the successive alveoles of the same series, we may easily conceive that the walls of contact in contiguous cellules should be double. This fact he has ascertained from decomposing specimens of *G. priodon;* and we have the same evidence in some of our species. In the cellules of the ordinary mode of development, each one is an independant part of the organization, and is provided with its individual body and cell-walls, as if each cellule were isolated. Whenever two of these are in contact, the cell-walls coalesce as far as the contact continues; but when becoming free, the cellule assumes its normal condition. In some specimens of *Phyllograptus* we find this evidence of double walls in the cell-partitions.

In *G. putillus*, illustrated on plate A, figs. 10, 11, and 12, the cell-walls, although contiguous to and adjoining the walls of the body (and not free), do not coalesce, but are readily separable without fracturing their substance.

There are cellules however where the production of the calycle by budding from the common body is not so obvious. These forms are like *G. bicornis* and *G. antennarius*, where the orifice is a simple transversely-oval aperture in the side of the stipe. In the flattened specimen it appears like a rectangular or slightly oblique, semi-oval notch in the margin. Its true form is perceived only when the cavities of the polyp have been filled with mineral matter, or when the stipes are flattened vertically against the apertures: they then give the form which has been described as *G. scalaris*. This form of cellules is shown on plate A, figs. 1 and 2, which are enlarged from a specimen retaining nearly its original proportions. Just within the limits of the cellules, and extending the entire length of the stipe, there is a longitudinal depressed line; and along this line, and running thence almost rectangularly to the outer limits of the stipe just above the aperture, the cell-partitions join the exterior test, and project in an extended border or flange.

In specimens stripped of the test, where the interior has been filled with stony matter, the cell-partitions present the appearance shown in fig. 3, plate A; while there is a large central space apparently occupied by the common body, but without the appearance of a central axis on the exterior surface. When the surface is ground down to a plane intermediate between the exterior and the centre, it presents the aspect of fig. 4; and when the cutting is carried to the centre, it gives the characters of fig. 5, the cell-divisions apparently reaching to the axis.

The general form of this stipe in section (fig. 6) approaches that of *Retiolites*, as shown by Barrande and Geinitz; and in the arrangement of the common body and axis there is a departure from the typical diprionidian forms of *Graptolithus*. In this transverse section we have a somewhat concavo-convex form, which is narrower on the concave side. There is a central or sub-central point indicating the filiform solid axis; and on each side of this are the divisional cell-walls, which produce a slight contraction of the exterior walls of the stipe at the inner limit of their attachment. Another section, fig. 7, shows the same features, together with the remains of two other cell-divisions, neither of which reach to the exterior walls of the graptolite; and the one on the right hand shows the narrow extremity just before joining the axis.

These sections, together with numerous other longitudinal, transverse and oblique sections, compel us to conclude that this graptolite possesses a filiform central or sub-central apparently solid axis; and that the cell-partitions originate from, or are joined to this axis. These cell-partitions appear to consist of triangular plates, which have an unequally arching or convex upper surface, and a concave lower surface. This form of cell-partitions would leave the alveoles to communicate at their bases with the common body on each side.*

In some forms having cellules of this character, as in *G. bicornis* proper, there is, in the flattened stipes, an external ridge, as if indicating the junction of the axis with the external walls. But in examples where this axis extends beyond the celluliferous portion of the stipe, it is compressed, having the aspect of a flattened cylindrical filiform body. It has no appearance of having been flat, or laterally extended within the body of the stipe.

In the ordinary forms of graptolites the orifice of communication between the cellules and the common body is usually round, oval, or quadrangular;

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* The cell-partitions in this form of graptolites are represented as they appear to exist in the solid specimens examined, on plate A, fig. 9; where, curving gently downwards on their exterior margins from the upper edge of the orifice, they turn more abruptly towards the axis, while the central portion extends obliquely to the axis, leaving a broad arch above, which gradually becomes angular as it approaches the axis.

and this appears to be true of all the species with a single range of cellules, and also of the ordinary forms of those with two ranges of cellules, where the common body is divided by a longitudinal axis.

In *Retiolites*, where there is no well-marked division limiting the common body, the union of the cellules with it is not so well defined; nor does there appear to be in these forms a continuous cell-partition: the cellules open in a quadrangular aperture, which is a little oblique to the transverse diameter.

In those graptolites with the simple transversely-oval orifices in the test, as *G. bicornis*, the arrangement of the common body and the communication of the cellules differ from all the other forms. There is an apparent double communication with the common body, giving not only the usual bilateral arrangement of the parts generally, but a bilateral arrangement of the parts in the individual alveoles.

The external orifice of the cellule in graptolites is extremely variable in form, and in its relative direction to the body of the cellule, and to that of the general axis. In a large proportion of the species, the aperture is oblique to the axis of the cellule, a little expanded, and thickened at the margin. The lower or posterior edge is often prolonged into a mucronate point or expansion. This feature, combined with the various degrees of curvature at or near the aperture, produces a great diversity of external expression in the orifice.

In *G. nitidus*, plate i, and in *G. similis* and *G. extensus*, plate ii, the plane of the orifice is nearly rectangular to the axis of the cellule; while in *G. bifidus*, *G. pennatulus*, and others, the margin is produced into a strong mucronate extension. In *G. octobrachiatus* the line of the cell-margin makes an angle of more than 90° with the axis of the cellule.

In mature individuals of *G. Clintonensis* the upper part of the cellule is re-curved, and the orifice opens downward nearly at right angles to the general axis, having a slight spreading and thickening of the border. In less mature individuals the orifice is apparently angular, and opens upward, while the plane of the aperture makes less than a right angle with the direction of the general axis. It would appear that in the progress of growth the cell-walls are continued, gradually contracting above, and, after becoming free from the adjacent cellule, form a slender, gradually curving tube, which in mature individuals has its orifice directed backward.

In *Dendrograptus*, the form of the orifice and outline of the aperture present variations similar to those of the simple uniserrate graptolites; but some species show modifications in the form of the cellule which do not accord with the more simple forms. In *Dictyonema*, the cellules are not fully known; the orifices are marked by a prominent mucronate extension, and apparently simulate the more common forms of graptolites. (Fig. 5, plate B.)

In the bi-celluliferous species the compressed specimens present the plane of the orifice, sometimes rectangular to the general axis, sometimes with the outer margin a little advanced, making an acute angle with the axis of the cellule, while sometimes the plane of the margin of the aperture is rectangular to the axis of the cellule, or rarely makes with it an obtuse angle. The cellules of *Retiograptus*, which have not yet afforded means of satisfactory examination, apparently have their orifices nearly rectangular to the general axis of the stipe.

In one of the forms of the bi-celluliferous graptolites the cellules are sub-elliptical tubes, with an orifice of corresponding form, without extension beyond a slight thickening or callosity at the margin of the orifice. The plane of the cell-aperture in this one makes an obtuse angle with the direction of the general axis.

In forms like *G. bicornis* the external orifice is transversely oval, with or without a projection and thickening of the test from the cell-partition above the orifice, or extension of the test.

4. *Ornaments of the Test.*—The compressed condition in which the graptolites usually occur is unfavorable to the preservation of any minute surface-markings, or ornaments of the test.

In many of the species, fine striæ, parallel to the margins of the cell-apertures, are perceptible, and in the larger number of species this marking is all that is preserved. There is sometimes a granular appearance of the surface, but I have not been able to satisfy myself that this is the actual surface-texture ; it may be a condition induced by mineralization. In a few examples there is a row of minute pustules at the base of, and corresponding to the cellules.

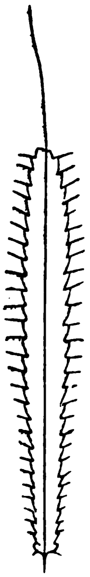
The stems and branches of *Dendrograptus*, *Callograptus*, and *Dictyonema* are irregularly striated. In typical species of *Retiolites* the test is finely reticulate ; while in the species from the Quebec group, this texture, if existing, is so fine as not to be readily resolved by an ordinary lens. The surface however has not the appearance of entire smoothness, as in most of the ordinary graptolites.

The chief ornaments of these bodies are the mucronate extensions of the test, usually from the lower margins of the cellules, but sometimes from the upper margins. In ordinary forms of the species, with single, and with double ranges of cellules, the mucronate or setiform extensions are usually from the lower extremity of the cell-aperture, as illustrated in fig. 29.

In all those forms of which *G. bicornis* may be regarded as the type, these processes, when existing, are extensions of the test above the aperture, so far as observed (pl. A, figs. 1, 8, 9) ; or as in species of the character of fig. 20, plate A.

In some species, as *G. quadrimucronatus* (plate xiii), there is a

Fig. 29.



Graptolithus Whitfieldi:

twice enlarged.

mucronate point extending from each angle of the cellule ; as also in *G. testis* of Barrande ; except that in the Canadian species these appendages are more rigid.

In *Phyllograptus typus* and *P. ilicifolius*, these processes are apparently the extension of the angles of the cell-partition.

The cellules of *Dendrograptus*, *Callograptus*, and *Dictyonema* sometimes show mucronate extensions from their outer margins. In *Retiolites* the cellules sometimes terminate in a plain margin, and in one species the divisions are extended in short strong mucronate points. (Plate B, figs. 5 and 21, and plate xviii, fig. 6.)

All the species of *Retiograptus* have the margins of the stipes garnished with slender mucronate points, corresponding to the cellules, and extending almost rectangularly to the axis. (Plate xiv, figs. 6–9.)

These ornaments are not always uniformly developed in the same species, or even in the same individual. In the larger proportion of specimens of *G. ramosus*, the margins of the cellules are apparently plain; but in the cellules of the simple part of the stipe we sometimes find a rigid mucronate point, prolonged from the upper margin or limit of the cell-aperture. (Plate A, fig. 20.) In *G. sextans*, the mucronate point is half-way between the two cell-apertures.

In specimens of *G. sextans*, and in some allied forms from the Hudson

River formation at Marsouin, Canada, the stipes and cellules are less fully developed than in those of the same species from Norman's Kill near Albany, while the mucronate extensions from the cell-apertures are more conspicuous.

Besides these ornaments, there is on each side of the radicle or initial point at the base of most of the diprionidian species of graptolites, a small process, varying in length, and usually directed downwards. These processes are usually short, but often considerably extended; in some species they are very slender, while in others they are strong and rigid. In *G. pristis* they are frequently seen as short slender processes; while in *G. bicornis* they are rigid, strong, and slightly curving. In *G. antennarius*, a congener of the latter, they are long and slender setiform appendages. In one species of *Retiograptus* they are slender setiform processes, directed downwards.

In no species of *Phyllograptus* have such appendages been observed; nor have they been seen at the bases of the stipes of *Retiolites*.

§ IV.—MODE OF REPRODUCTION AND DEVELOPMENT IN THE GRAPTOLITIDÆ.

As already remarked, the graptolites proper are now generally referred by authors to the Radiata; while some forms which I include in the family have been heretofore regarded as reticulate bryozoans, or as gorgonians. The nearest analogues in the recent fauna appear to be among the group Pennatulidæ, or in the Sertularidæ; but in all these there is no absolute identity in the mode of development or character of cellules, so far as my observation has extended.

In nearly all the true bryozoan forms among fossils, we have the means of tracing the relations and analogies, both in manner of growth and reproduction, throughout all the successive geological periods, and in the present fauna. It becomes therefore more difficult to discover such analogies for the Graptolitidæ, since the graptolites proper disappear from existence in the Silurian period; and the latest form of Graptolitidæ (*Dictyonema*) is not found, so far as now known to me, in American strata, at a later period than the Hamilton formation or Middle Devonian. From this cause, the mode of growth and development are not so readily understood as in those families which can be traced throughout the geological series, and still find their analogues in the present seas.

In 1858, I laid before the American Association for the Advancement of Science a notice, with some illustrations of graptolite stipes, bearing what I then regarded, and do still regard, as the reproductive cells or ovarian vesicles. These cells first appear as small ovate buds upon the margins, projecting but little beyond the regular cellules, and, becoming enlarged, form elongated sacs with swollen extremities, which are finally dehiscent; and then, as I suppose, discharging the ovules or germs, are gradually absorbed or dissipated.

Although these sacs are distinctly defined, they have scarcely any apparent substance, except along the lateral margins, which are limited by a filiform extension resembling the solid axis of a graptolite. There are likewise numerous fibres of this kind traversing the sacs; and these sometimes remain attached to the original stipe after the other parts are separated. In one example, we have conclusive evidence that they are connected with the solid axis of the parent stipe. The gradations of development in these sacs may be studied in the figures 6–9, plate B.

In the specimen fig.10 of the same plate the ordinary cellules are removed, and the fibres are still seen joined to the axis, showing the origin of the reproductive sacs. In most specimens bearing these sacs, the cellules of the stipe are so obscure that the species cannot be determined; but in fig. 9 we find them attached to a well-marked stipe of *G. Whitfieldi.*

This mode of reproduction in the graptolites shows much analogy with the Hydroidea, and would indicate the sertularians as their nearest analogues.*

Upon the surfaces of the slate where these bodies occur, there are numerous graptolitic germs, or young graptolites of extremely minute proportions, ranging from those where the first indications of their form can be discovered, through successive stages of development till they have assumed the determinate characters of the species.

In several examples, these minute germs have been detected near to and in contact with the reproductive sac; and in one case, there is but a hair's-breadth between one of the fibres of the sac and one of the oblique processes at the base of the germ. It cannot be said that we have detected the germ actually within the sac; but the numerous young individuals lying near them, and upon the surfaces of the same laminæ, offer very good arguments for supposing that they have been thus derived.

The earliest defined form which we observe in the young graptolites

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*In the recent *Sertularia* and *Campanularia* we find ovarian vesicles, in which a number of ovules may be enclosed in a common envelope. These vesicles are developed along the side of a stipe or branch, and the ovules are often arranged along a central axis, each one communicating with the common axis of the zoophyte. [Jas. J. Lister, *Philosophical Transactions*, 1834, pp. 365–388, pl. ix. Cited also by Dana, "*Structure and Classification of Zoophytes.*"]

Prof. McCoy has stated (*British Palæozoic Fossils*, p. 4) that he has found near the base of the cellules of graptolites, a transverse partition or diaphragm, similar to what may be observed in some sertularians, and which he regards as proving similar relations; but I have not discovered in any American specimens evidence of such cell-diaphragms.

consists of the initial point or radicle; a diverging process of similar character on each side, but not quite opposite; a longitudinal axis of greater or less extent; and a sac-like covering, or thin pellicle of graptolitic test, which has scarcely assumed the form of cellules, but which is most extended in the direction of the common body along the solid axis. This little sac contains the germ of the zoophyte, which, extending itself as the common body in its canal along the axis, gives origin to the budding which develops the successive cellules and the gradual building up of the stipe.

The earliest condition of development is illustrated in fig. 12 of plate B.[*] At a farther stage of development we have the form better defined, as in fig. 13, where the germ has assumed the general aspect of *G. pristis*, the slender lateral processes being rectangular to the axis.

On the left hand of fig. 8, and at the third reproductive sac below the top, there are two germs visible, close to the sac, where the connection between one of these and the fibre is nearly complete. The same is shown in the enlarged fig. 11.

In figure 14 we have the germ of another form, which is unequally developed on the two sides. Figure 15 (represented of the natural size) appears to be of the same species, having reached a more definite form. Figure 16 is an oval disc, of which several more or less defined specimens have been found among the young graptolites, but I have not been able to trace it to any known mature form.

The specimens figs. 17 and 18 appear to be the young of *G. bicornis*, or of a similar form. In one the body is narrow, without marks of cellules, and the solid axis is not extended above the common body, being probably broken off. In the other there is a greater expansion of the common body, but no cellules are visible, and the central portion of the substance is more dense, while towards the margin it is extremely thin; the solid axis is extended beyond the stipe, and the lateral oblique processes are quite perfect. This germ, with its axis and common body, had not begun to develop the cell-apertures on its margins, which may be seen at a later period.

In nearly all the young graptolites there is an extension of the common body along the axis above the incipient cellules. This is observed in the figures referred to and in the young of *G. ramosus*, shown six times enlarged on plate A, fig. 21.

Although I have found none of the monoprionidian forms with reproductive sacs attached, I have nevertheless observed what appear to be the young of some of these species, having an aspect similar to the others, except in carrying the development upon one side only of the solid axis. An illustration of one of these forms is given in fig. 19, plate B, showing the base irregularly divided. These forms cannot be referred to any known mature species.

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[*] All the specimens of germs or young graptolites are six times enlarged, except figs. 11 and 17.

This mode of development, illustrated in numerous specimens, can be readily understood in the simple stipes whether of the monoprionidian or diprionidian character. Admitting that the examples given furnish evidence of the mode of reproduction of the diprionidian forms, or those of the sub-genus *Diplograptus*, where we have a range of cellules on each side of a solid axis, it is easy to perceive how the germ of an analogous form may develop from its initial point two series of cellules upon a stipe, where the parts diverge in opposite directions from the common origin or initial point. One step farther in this direction will give us the four-stiped forms, where the germ of the common body, with its additional elements of subdivision, produces the quadripartite frond; and so onwards, until we have the numerously-branched fronds and the branching stipes.

In all these, the germ in its incipient development will differ very little. It may consist of the radicle or initial point, with the solid axis, and the common body, separated into two, four, eight, or an indefinite number of divisions, each one bearing its solid axis and common canal. These subdivisions sometimes all take place near the origin, which is always central; and the divisions continue simple throughout, or do not bifurcate after they commence to develop cellules.

In others the stipes are again divided, and this subdivision is only limited by the extent of the frond. In all these fronds the parts are always arranged symmetrically or bilaterally on the two sides of the initial point; as has been illustrated in the preceding pages.

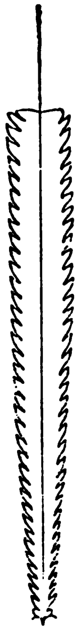
Throughout all the monoprionidian forms, or those illustrated on the first twelve plates of this memoir, we have only modifications of the simplest form of development shown in the species of plates i and ii. Where the divisions at the base become more numerous, (and indeed in the four-stiped species,) we find a thick corneous test, of the same substance as the other parts of the graptolite, uniting the bases of the stipes and continuing along their margins. This plate has a greater or less development, not always corresponding to the size or extent of the stipes. It is sometimes absent, apparently from accident, and some of the four-stiped species are not known to possess it; while it has never been observed in any of the species where the stipes are properly branched, or divided in the celluliferous parts of their length.

The interior of this corneous disc, previously described as apparently composed of two plates of the test, has probably been occupied by some softer substance, which may have been an extension of the common body, or have had in some degree the character of the common body of the stipe.

The development of the diprionidian forms, as deduced from the young graptolites which we find associated with the reproductive cell-bearing stipes, would show that these forms of graptolites exist as single and simple independent stipes from the commencement of their growth. Nevertheless I conceive that both *Retiolites* and *Retiograptus* may have existed in compound fronds, having their origin from a central point not unlike in the commencement to *Graptolithus Logani*, but without the central disc. These fronds were probably concavo-convex, as were the individual stipes. The solid axis, instead of being central, is placed externally along the centre of the convex or outer side; and the cell-divisions on that side reach to and join it; while on the upper or concave side the cell-divisions do not reach the centre, leaving a space for the common body, which has been shown by Barrande and Geinitz to produce a central longitudinal prominence.

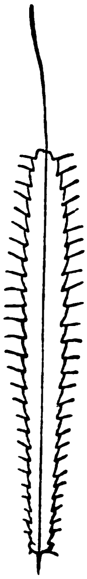
In these forms the mode of development has been similar to that already explained, the modification being chiefly in the external position of the axis and the joining of cell-divisions with the axis on one side; leaving the common body in a somewhat triangular form, from which the alveoles are developed on either side.

Fig. 30.



Graptolithus pristis: enlarged.

Fig 31.



Graptolithus Whitfieldi: enlarged.

Whether the *Phyllograptus* existed as simple stipes with four ranges of cellules, or in a compound arrangement as in *Retiograptus*, the mode of development has been similar: either the germ with its initial point developed a single stipe with four ranges of cellules, or the same elements first subdivided, and each division gave origin to its stipe through the common body.

In regard to the development of the cellules in the different parts of the graptolite, we observe, as a uniform feature, their lesser development towards the base of the stipe. In all the monoprionidian forms this character is particularly observable; and in a few species the earlier cellules are raised in a scarcely perceptible elevation above the general surface of the common envelope. Indeed in a few instances it is impossible to ascertain satisfactorily whether these earlier prominences are expanded into open cellules. As the stipe is extended, they become gradually more and more prominent, until towards the middle, or oftener perhaps nearer the distal extremity, their greatest degree of development is reached. In some species this takes place near the base, and in the more elongated stipes there is no sensible increase throughout a great part of their length, and the two margins of the stipe are essentially parallel. Towards the distal extremity there is a gradual, or often a more abrupt, diminution in the size of the cellules, and a few of the last ones are much smaller, until the terminal cellule is sometimes seen in a partially developed condition between the common body and the partition of the preceding cellule.

The same condition of development in the cellules is true of the diprionidian forms, as is shown in some degree in *G. pristiniformis*, plate xiii, but more especially in the accompanying figures of *G. pristis* and *G. Whitfieldi*, the last of which shows the higher cellules diminished, so as to contract the width of the stipe above (figs. 30 and 31, p. 36).

In *Retiolites* and *Retiograptus*, the full development of the cellules takes place below the middle of the length of the stipe, while they are less developed towards either extremity. In some species of *Retiolites*, including one from the Clinton formation, the cellules acquire their greatest development near the base, and the margins are essentially parallel for the greater part of their length.

In *Phyllograptus*, the lesser development of the cellules at the base of the stipe is a marked feature. They increase rapidly towards the middle; and their greatest development is sometimes above and sometimes below the middle, but in all cases becomes rapidly less towards the apex.

In *Dendrograptus*, where we have a stout stem without cellules, the branches usually begin at some distance above the base: and in their lower part they have scarcely the appearance of being celluliferous; in the middle of their extent the cellules become more distinct, and so far as can be observed they are less developed towards the extremities.

§ V.—MODE OF EXISTENCE.

The numerous individuals of entire or nearly entire fronds illustrated in this memoir, as well as large numbers of others examined, serve to give a pretty clear idea of the general form of the true Graptolites, as well as of their congeners of the same family. Notwithstanding the presence of the radicle or initial point observable in so many species, it does not afford evidence of attachment to the sea-bottom or to some other substance, at least in the mature condition. In all the monoprionidian forms, however much or little extended the radicle may be, it is always smooth, and tapering to a point. In many of these, and more especially in those with a central disc, this radicle is reduced to a minute protuberance, and is often scarcely or not at all perceptible.

The same is essentially true of the greater number of diprionidian forms examined. In these the solid axis is sometimes extended beyond the base of the stipe, and terminated as if broken off abruptly; while there is often a slender oblique process on each side of the base.

In *Retiograptus* and *Phyllograptus* there is not the same evidence of completeness at the base of the radicle. The lower termination, when it can be fully examined, is broken, as if there had been a further continuation of this part, though it exhibits no enlargement. I have inferred that all these, like the example of *Retiograptus eucharis* (fig. 9, pl. xiv), have constituted parts of a similar compound body, and are but the separated stipes of the frond. If this be true, their mode of existence is not unlike the other species with compound fronds and a central disc.

In *G. bicornis* the extension of the solid axis below the base of the stipe is not always preserved; but when it is entire, we find two strong, diverging and slightly curving processes or spines from the base, having smooth terminations. Sometimes a disc or bulb, of the same substance as the stipe, extends between these spines, and in the compressed condition envelopes a few of the lower cellules, as shown in fig. 17, plate A. Some of the phases presented by the basal extremities of this species are shown in figs. 13, 15, 16, and 17 of the same plate.

The expansion at the base of this species has the same general appearance as the central disc of *G. Logani*, *G. Headi*, and others; showing that this sort of development of the substance is not alone characteristic of those forms having several stipes united at the base. In other examples this basal expansion is contracted in such a manner as to give a crescent-form to the lower extremity; but in all these gradations, the margins of this part are entire and unbroken.

We have seen that the youngest forms of the diprionidian graptolites, those which we may suppose had but recently escaped from the reproductive sac, are furnished with the minute radicle-like appendage or extension of the solid axis, as well as the oblique lateral processes like tentacula; and the condition of these parts does not seem to have been essentially changed during any subsequent period of their growth. While the extension of this slender solid axis does not seem of sufficient strength to have formed the base of attachment to the sea-bottom, it may have been sufficient to maintain connection with other parts of a compound frond.

For all those species with a single range of cellules, as well as for some with a double range, including *Retiolites*, *Retiograptus*, and *Phyllograptus*, I conceive that we have already shown a similar plan of development and a uniform mode of existence; and we are constrained to believe that all these forms, in their mature condition, were free floating bodies in the Silurian seas.

In regard to another group including *Dendrograptus*, *Callograptus*, and *Dictyonema*, as well as one or two other forms, we have some evidence indicative of a different mode of existence. The stems of *Dendrograptus* are enlarged towards their base, and sometimes present a sudden expansion or bulb, which I have inferred may be the base or root, once attached to another substance or imbedded in the mud. The general form of the species conduces to the belief that they were fixed to the sea-bottom, though possibly this basal expansion may have resembled that of *Graptolithus bicornis*. In most of the species described, the lower extremity is imperfect, and its termination unknown.

In those which I have termed *Callograptus*, the bases of the fronds are imperfect, but indicate, according to analogy, a radicle or point of attachment like *Dendrograptus*. In the more nearly entire forms of *Dictyonema* known, we have not been able to observe the base; but from their similarity in form and mode of growth to *Fenestella* and *Retepora*, we have inferred their attachment either to the sea-bottom or to foreign bodies.

Nearly all these forms occur in rocks where there are few of the larger fossils of any kind except the graptolites; so that there is little chance of finding their bases attached to shells and corals, as we do those of the bryozoans, even if they had thus existed. The *Dictyonemæ* of the Niagara, Upper Helderberg, and Hamilton groups do occur in strata which contain large numbers of other fossils; but we have no evidence of their having been attached. It is only from their general form therefore, and from their analogy with other bodies, that we infer that these genera may have been attached to the sea-bottom or to some objects during their growth.

We admit therefore that the family of Graptolitidæ, as now extended, may include both free and fixed forms.

§ VI.—GENERAL CHARACTERS OF THE FAMILY OF GRAPTOLITIDÆ; WITH REFERENCE TO THE DISTINCTIVE FEATURES OF THE GENERA, AS KNOWN IN THE GEOLOGICAL FORMATIONS OF CANADA AND THE UNITED STATES.

In the first section of this memoir, I have remarked upon the nature and general form of the graptolites proper, and the allied genera which I regard as belonging to the same family. The large accession to the number of species, and the great variety of new forms added to those formerly known, require an extension of the characters heretofore given.

The numerous graptolites described by Nilsson, Hisinger, Bronn, Murchison, Eichwald, Portlock, Geinitz, Barrande, Suess, McCoy, Salter, Harkness, Nicol, Meneghini, myself, and others, were for the most part in a fragmentary condition, affording knowledge only of the simple stipe, the structure of its parts, and the arrangement of the cellules. From these fragments however we have derived the generic characters; while the modifications in form, and the order and relations of cellules, have furnished means of specific distinction in the greater proportion of those described.

In maintaining the generic term *Graptolithus* for the forms which have the nearest relations with those to which the term was originally applied by Linnæus, M. Barrande has proposed two sub-genera, characterized by the presence of a single series, or of two parallel series of cellules, under the names of *Monoprion* and *Diprion*. The latter term having been applied to a genus of insects, the name *Diplograptus** of McCoy has generally been adopted.

The distinction indicated would at one time have expressed a character perfectly trenchant; but the discovery of such forms as *G. ramosus* † and *G. furcatus*, shows the occurrence of both a single and a double series of cellules upon the same stipe, or, more properly, shows the basal portion consisting of a stipe, with two parallel ranges of cellules. The stipe, dividing at some distance above its origin, is continued as two simple stipes, each with a single range of cellules. These cellules are on the outer margin, and are a continuation without interruption from those of the lower part of the stipe. Including these therefore in the same group with *G. pristis*, the subdivision indicated would have less value for the purposes of study; but I believe these latter forms may be separated on other grounds, as will be shown farther on; so that with our present knowledge we may still recognize *Diprion*, = *Diplograptus*, as a well-marked and clearly-defined sub-generic group of the *Graptolithus* proper, having such forms as *G. pristis* among the typical species.

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* In the genera proposed by myself, I have chosen the termination *graptus* instead of *grapsus*, since the latter termination is in use in the nomenclature of crustacea.

† The subdivision of this species beyond the first bifurcation, represented in the Palæontology of New York, vol. i, pl. lxxiii, fig. 3, is erroneous; the specimen consists of two individuals, the base of one being placed directly in the axil of the other.

Mr. Geinitz has more recently proposed the name *Monograptus* to include *Monoprion* and *Rastrites* of Barrande; placing under this genus, as his typical species, *G. sagittarius* of Hisinger, which is the typical form of *Graptolithus* of Linnæus.

The genus *Cladograptus* * is also proposed by Mr. Geinitz, to include the species *G. ramosus* and *G. furcatus*, Hall, *G. Murchisoni*, Beck, *G. serra*, Brong., *G. Forchhammeri*, Geinitz, and *G. sextans* and *G. serratulus*, Hall. At the same time the British palæontologists, adopting the name *Didymograptus*, McCoy, place under that genus *G. Murchisoni*, Beck, *G. caduceus*, Salter, *G. sextans*, Hall, *G. geminus*, Hisinger, *G. hirundo*, Salter, and other similar forms. Those which are made the typical forms of the genus by Geinitz are the "species *gemellæ*" of Bronn, who included under that term the *G. geminus*, Hisinger, and *G. Murchisoni*, Beck, which are by no means nearly related to *G. ramosus* or *G. furcatus*. The first-named two species, which were the earliest known of that character, and regarded as the typical forms of *Didymograptus*, are similar to *G. bifidus* and *G. extenuatus* of this memoir, which differ from the other species on plates i, ii, and iii, only in the lesser divergence of the stipes.

Very recently Mr. Salter has proposed a further subdivision of the graptolites under the name *Tetragraptus*, "a kind of double *Didymograptus*," of which *G. bryonoides* is made the typical species; and *G. quadribrachiatus* is referred to the same genus. He also proposes *Dichograptus* for those having the "fronds repeatedly dichotomous from a short basal stipe into eight, sixteen, twenty-four, or more branches, each with a single row of cells." "But the main character which distinguishes *Dichograptus* is the presence of a corneous plate † which envelopes all the lower part of the branches, and which is not known in any other genus of the group; it has not indeed been seen in more than two or three species of *Dichograptus*, but it may not in all cases have been preserved." ‡

These subdivisions may be of some value when the entire frond and all its appendages are preserved, but unfortunately this is rarely so; and when we have but fragments of the stipes or branches, there is no force or value in the application of these terms: we are thus reduced to the necessity of adopting the old term *Graptolithus*. Again, the value of *Didymograptus* I conceive to be pretty well illustrated in the case of *G. caduceus*, the original of which is cited from Lauzon, Canada.* After studying the large collections of graptolites made by the Canadian Geological Survey, I am compelled to believe that the *G. caduceus* was founded upon such forms as I have represented on plate xvi, figs. 22, 23, and 24; for we have no two-stiped species or forms of "*Didymograptus*" with a pedicle or radicle so long as that represented in the figures of Mr. Salter, nor any one so abruptly recurved; and I regard the apparent radicle in the two examples figured as simply one of the four stipes imbedded in the shale, and exhibiting its non-celluliferous margin and a small portion of its width, as I have shown in the figures cited.

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* CLADOGRAPSUS, Geinitz. Syn. *Graptolithus auctorum;* species *gemellæ*, Bronn. (Die Versteinerungen der Grauwacken formation in Sachsen, etc. Heft. i, *Graptolithen*, p. 29.) MONOGRAPSUS, id., ibid., p. 42. Syn. *Monoprion* et *Rastrites*, Barrande; *Graptolithus*, Suess.

† First discovered in the graptolites of the Quebec group at Point Lévis.

‡ Quarterly Journal of the Geological Society, vol. xix, p. 136.

Other varieties of this form show only the two simple stipes, with a slight process in the centre. We have therefore a "*Tetragraptus*" in a condition undistinguishable from a "*Didymograptus*"; and the same may happen in *G. bryonoides*, as shown in plate iv, fig. 5, where the quadripartite stipe is separated into two; and in the separated stipes it is impossible to know if there have been two, four, or eight in the entire individual. With regard to those fronds which are repeatedly dichotomous, forming the genus *Dichograptus*, of which the distinguishing character is the central "corneous plate which envelopes all the lower part of the branches," we may remark, that we have three or four species of the four-stiped form, or "*Tetragraptus*" with the central corneous plate; while we have four species which are not known to possess it. Of the two eight-stiped species known, one has the central corneous plate or disc, and the other was probably destitute of such an appendage. In *G. Logani*, with its numerous simple stipes, the central corneous plate is usually present, though not in all examples; while *G. multifasciatus*, with more numerous simple stipes than *G. Logani*, is not known to have a central corneous disc, and, from its mode of growth, probably never possessed such an appendage. From the irregularity of growth in the *G. abnormis*, I infer that there was no central plate.

In all the properly-branching species where the initial point is known, as in *G. flexilis*, *G. rigidus*, and *G. Milesi*, no such central plate has ever been seen; nor has it been shown in any European species, so far as I know. The frequently-bifurcating stipes, similar to the one originally proposed by Mr. Salter† as the type of *Dichograptus*, are not known to possess the central corneous disc.

Although entirely willing to accept and adopt such subdivisions of the graptolites as will aid in determining their zoological character and relations, their geological value, or indications of differences in mode of development, I do not appreciate at the present time the force and value of the proposed generic subdivisions for the two, four, and eight-stiped species, or the presence or absence of a central corneous disc as indicating generic distinctions; since it is impossible to obtain any aid from such designations for the references of the numerous fragments which are the ordinary form and condition in which we find the graptolites, and in which they must generally be studied.

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* *Graptolithus caduceus*, Salter; Quarterly Journal of the Geol. Society, vol. ix.

† Geologist, vol. iv, p. 74, 1861.

The form, mode of growth, and arrangement of cellules in all these several proposed genera, are so identical in plan as to afford no means for generic separation; and although the same is true of the properly-ramose forms, yet I conceive it might have been convenient to adopt a term (*Dichograptus* or *Cladograptus*) indicating the ramose character of the stipes, regarding as true branches only the subdivisions which take place after the commencement of the cellules.

The genus *Nereograptus** of Geinitz, proposed by that author to include such forms as *Nereites*, *Myrianites*, and *Nemertites* of Murchison, and *Nemapodia* of Emmons, etc., can scarcely be admitted into the family of Graptolitidæ, since all the American species referred to the first three named genera have no texture or structure like graptolites, and (as I have elsewhere shown) appear to be referable to the tracks or trails of some marine worms or other animals upon the sea-bottom; while *Nemapodia* is simply the trail of an existing slug upon the slightly lichen-covered surfaces of the slates.†

The genus *Glossograptus* of Emmons is founded upon a species of *Diplograptus* with ciliate appendages on the cell-margins; and no characters are given to show its generic distinction. The typical species of *Nemagraptus* (*N. elegans*) is apparently a part of an individual of *Graptolithus gracilis*, or of some similar species; while the relations of the second species of the genus (*N. capillaris*), an elongate, flexuous, filiform body with a few branches at irregular intervals, can scarcely be determined from the figure given.

The typical and only species of *Staurograptus* ‡ of the same author is a very remarkable form of extremely minute proportions. Its mode of growth and subdivision of stipes, if accurately represented in the figure, are unlike anything known among this family of fossils, and it merits generic distinction.

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* *Nereograpsus:* Die Verstein. Grauwacken formation, etc., Graptolithen, p. 27.

† These markings can be easily removed from the surface of the laminæ by washing with water; and they can be traced over the exposed surfaces of the edges of the successive laminæ.

‡ *Glossograpsus, Staurograpsus, Nemagrapsus:* Emmons, American Geology, part ii, pages 108 and 109.

The term *Diplograptus* is properly applied to such forms as *Graptolithus pristis*, Hisinger, *G. palmeus*, Barrande (excepting figs. 5 and 6), *G. foliaceus*, Murchison, and *G. pristiniformis* of this memoir; where the cellules are disposed in parallel ranges on the two sides of the central axis, and are of the same or similar form and arrangement with those of monoprionidian form *G. sagittarius*, and with others of that type, in which we include all the species of the first nine plates of this memoir; the reason for the proposed separation being in the double range of cellules only.

In the ordinary forms of *Diplograptus* (plate xiii, figs. 15–17), as in the ordinary monoprionidian types, the cellules are usually closely arranged, and overlapping each other for a part of their length. In a single species (*G. putillus*, from the Hudson River formation in Iowa), which has come under my observation in some well-preserved fragments, we have so far a modification of the general arrangement of the cellules that the apex of one barely reaches the base of the next succeeding. The stipe is a strong elliptical tube with a flattened central solid axis, the line of which is marked on the exterior by a longitudinal undulating groove (fig. 10, pl. A). The surface is strongly striated transversely, and the sides studded with tubular cellules, which are alternately arranged. These cellules are sub-oval, flattened on the side adjoining the body of the graptolite, curving on the exterior free portion, and obliquely flattened at the base just above the aperture of the cellule next below, as shown in the profile view (fig. 11, plate A). The exterior test of the common body is swollen in oblique undulations in the direction of the base of the cellules, or where the individual buds take their origin; and the axis is curved towards the opposite side, as shown in fig. 10, plate A.

The transverse diameter of the stipe is about two-thirds as great as the longer diameter. The celluliferous face of the stipe shows broad elliptical depressions; the lower side, for little more than half the height, being the sub-oval cell-aperture; while the upper part is the semi-oval flattened area at the base of the next succeeding cellule, as shown in fig. 11, plate A. In this case the cellules are shown to be separate and distinct tubes, closely pressed against the lateral walls of the stipe on one side, and communicating with the common canal by a slightly narrowed passage, as shown in figure 12, plate A, which represents a longitudinal section of the body. In a transverse direction the base of the cellule is wider than the aperture (fig. 11, pl. A).

Specimens of this character, on becoming flattened, would present a form where the cellules, though inclined against the common body, would not overlap each other, and where the margin of the cellule is directed backward instead of forward. Were these cellules to be prolonged, they would overlap the next in advance, presenting in this condition but a slight modification of the usual forms of *Diplograptus*. These deviations from typical forms are so slight as to offer no sufficient ground for generic separation.

There are however a few examples, where the stipe is marked by a range of cellules upon each side of the central axis, which appear to be properly separated from *Diplograptus*, on account of the form and structure of the cellules. These are apparently quite unlike those of *G. pristis*, and others of that sub-genus. The *Graptolithus bicornis*, and two or three allied forms, when flattened in the shale, show, as already described, a simple semi-elliptical notch in the margin of the stipe, nearly rectangular to the axis. This is well shown in fig. 3, plate vi, of M. Barrande's memoir, and also in Mr. Salter's illustrations of *Graptolithus teretiusculus* of Hisinger.* It is represented, less perfectly, in the figures of Prof. Harkness,† and in most of my own figures on plate lxxiii of the first volume of the Palæontology of New-York. When compressed rectangularly to the cellules, the apertures are transversely oblong-oval; and the same form is shown when looking upon the celluliferous margin of an uncompressed stipe.

The structure of these stipes and their cellules has already been described in a preceding section, with reference to the figures illustrating the same. The *G. bicornis*, known in New-York and Canada, may be considered the type of a group of species of which we have two in the shales of Norman's Kill near Albany, one in Ohio, and a similar or identical form in the Utica slate at Collingwood in Canada West. I would include in the same group figs. 5 and 6 of plate iii, as well as figs. 7, 8, and 15, plate ii of M. Barrande's Memoir; *Graptolithus teretiusculus* of Hisinger; and those referred to the same species by Salter.‡ The *Diplograptus rectangularis* of McCoy || is of the same type, as also figs. 1, 5, 10, 11, 12, etc., tab. ii, of Geinitz (*Graptolithen*); and I conceive that many, if not all of the scalariform specimens, belong to species of this character.

The *Graptolithus ramosus* has usually been arranged by authors under *Diplograptus;* the lower part of the stipe having a double range of cellules, while it is bifurcated above, with the cellules on the outer margin of each division, as already described; and a simple explanation of this condition has been offered by supposing that the solid axis has been separated after the death of the zoophyte. This however will scarcely afford a satisfactory argument when we find that all the specimens are in the same condition; that usually the division begins at a uniform distance from the base; and that, when entire, the divided portion much exceeds the

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* Quarterly Journal of the Geol. Society of London, vol. viii, pl. xxi, figs. 3 and 4.

† Id. Ibid., vol. vii, pl. i, fig. 11.

‡ Quarterly Journal of the Geological Society, vol. viii, pl. xxi.

|| British Palæozoic Fossils, page 8, pl. xiii, figs. 8, 9, and 10.

simple undivided part of the stipe. Moreover, the species is recognized in this condition in the Hudson River formation in Canada, and has likewise been recognized in Great Britain; while a similar or identical form has been shown by Prof. McCoy to occur in Australia. We must therefore seek some other than an accidental cause for the explanation of this uniform bifurcation of the stipes of that species. In the meantime, it appears to me highly proper to suggest its separation from *Diplograptus*.

On farther comparison, we shall find that *G. ramosus* is not quite alone in its peculiar characters. In *G. furcatus* there are a few cellules at the base of a simple stipe below its bifurcation; and in *G. sextans*, the lower part of the stipe is simple, the division taking place above the first cellule; but in entire individuals the division is never from the initial point, as we see it in *G. bifidus* and *G. nitidus* of this memoir.

Now these first-named species, as well as *G. ramosus*, have cellules of a peculiar form; and looking still farther, we find a similar form of cellule in *G. Forchhammeri*, Geinitz, and *G. divaricatus*, Hall, two species which are divided from the base, having a single range of cellules upon the outer sides of the stipe. I believe it will be found, moreover, that all the graptolites with cellules on the lower side of the stipes (in reference to the initial point or radicle) have these parts of the same form as *G. ramosus*, and very unlike the *G. pristis* and allied species. Nor are the cellules on the simple or divided portions of the same stipe, or on those which are entirely divided and upon the lower side, at all like the cellules of *G. priodon*, *G. geminus*, *G. Murchisoni*, or any of the allied forms illustrated in this memoir, to which the term *Didymograptus* has been applied; nor can they be properly united with them. The form of the cellules is always sufficiently distinctive even in fragments of the stipes; and this feature, together with the mode of development or growth, seems to me sufficient to sustain a generic distinction.

The genus *Retiolites* is described by M. Barrande as having no central solid axis, but with a single internal canal occupying the median portion of the polyp. The prevailing form of the stipe is somewhat concavo-convex, with the centre of the concave side prominent; the entire surface is covered by a net-work of corneous substance, and the cell-apertures are quadrangular.

Prof. Geinitz has given some further illustrations, showing more emphatically a longitudinal axis on the convex side, to which are joined the cell-partitions; while he regards the common body as occupying the prominent central portion of the concave face of the stipe, and shows the cell-partitions terminating before reaching the centre, leaving a space occupied by the width of the common body. This he represents as covered by a net-work of slightly different texture from that of the other portions of the substance.

The Canadian specimens which I have referred to this genus are so extremely attenuated that it is impossible to determine the details of structure, and the surface-characters are obscure. Thus far we have no American specimens in a condition to afford the means of elucidating some obscurities which seem to me still to exist in regard to the intimate structure of this genus. The species of the Clinton formation is extremely compressed; and while some specimens show the cell-divisions terminating at a distance from the centre, yet, after protracted and repeated examinations, my most critical observations result in showing only the structure which is illustrated on plate B, figs. 20 and 21.

On one side we have an external, cylindrical, solid axis, to which the cell-divisions are joined; but these latter show only filiform cylindroid processes, extending from the axis to the cell-margin, and projecting a little beyond the margin of the stipe. The only other aspect which we observe in this species is that of an undulating or zigzag filiform axis on *the opposite side*, to which the cell-partitions are joined, as in fig. 21, plate B. We know this to be on the opposite side or within the stipe, as it is sometimes seen overlying the straight axis and cell-partitions.

At the junction of the cell-divisions with the zigzag axis there are other processes of similar character, projecting upward and outward from the axis, all of nearly equal length, but apparently broken at their extremities. I have not been able to determine any connection between these and other parts of the skeleton, but we have the two structures very clearly represented in the figures referred to. I have supposed that similar processes may have extended to the opposite side, from the junction of the cell-partitions with this undulating axis, either joining the cell-divisions or the straight axis; but after long investigation I have been unable to find satisfactory evidence of such connection. The cell-apertures are surrounded by thickened margins, and the only appearances of cell-partitions are the sub-external cylindrical extensions from the aperture to the axis. Neither the species of the Quebec group nor that of the Clinton formation, in any of the specimens seen, are in a condition to show evidence of the concavo-convex character of the stipe represented by M. Barrande and Prof. Geinitz.

The species of *Retiograptus*, while having some characters in common with *Retiolites*, do not possess the reticulated structure of the test in either of the described species. There yet remains some obscurity in regard to the internal structure of this genus, which can only be satisfactorily explained by the examination of better-preserved specimens. Nevertheless, in its general form, structure, and mode of growth, it is shown to be quite distinct from other graptolitic genera. The three species referred to this genus present differences which can only be reconciled by supposing that the two sides of the stipe are very unlike each other in form and external characters, as in *Retiolites*.

The species for which I have proposed the genus *Phyllograptus*, present close analogies with the typical form of *Diplograptus* in the character of test and form of cellules. These, in their aperture and form, are nearly quadrangular; and the cell-partitions are apparently continuous between the cellules, and reach nearly to the central axis; characters which we find in *Diplograptus*. These forms, in their great lateral extension, depart widely from their analogues; but they differ more essentially in their cruciform mode of growth, presenting an arrangement of parts, as if four simple stipes (like those of *G. bryonoides* or *G. Bigsbyi*) were joined together by the coalescing of the solid axes. In this latter respect, and in their great development in width, they differ most essentially from all the other genera of this family of fossils. These forms are fully illustrated on plates xv and xvi of this memoir.

In the typical species of *Dendrograptus*, as illustrated under the generic description, and in some of the species on plate xvii, we have a wide departure from the typical forms of *Graptholithus*, as developed in the characteristic species of the genus (plates i–ix). The strong stem or trunk, which is free from cellules, and which has apparently been fixed at the base; the irregular branching, which has no bilateral, and apparently no definite arrangement, such as observed in all the forms of true *Graptolithus*, are strong points of dissimilarity, and furnish characters for generic distinction. The stem and branches are unequally striated longitudinally, but the form of the celluliferous branches and of the cellules offers no important difference (except in the smaller dimensions) from those of the stipes or branches of the usual form of graptolites with a single series of cellules. In one species referred to this genus (the *D. gracilis*) there is some departure from the typical form of cellules, and the body of the stipe is contracted at intervals, while the form of cellule and cell-aperture is not unlike some of the Sertularians.

The genus *Callograptus* offers forms which are intermediate between true *Dendrograptus* and *Dictyonema*. In these species, the forms of the cellules have not been fully determined. They are marked in one species by slight oval pustules, or oval depressions, upon the extremely compressed surface of the stipe; but it cannot be satisfactorily shown that this appearance indicates the normal condition of the cellule or the aperture. If the true form be in reality so far different from the usual character of the Graptolitidæ as these appearances indicate, it may be found necessary to separate them from this family.

The genus *Dictyonema* is restricted to such forms as have the numerous stipes and branches connected by a transverse process, and the whole united in a flabelliform or funnel-shaped frond, without elongate stem or trunk. The stipes and branches are irregularly striated externally, consisting of a corneous envelope, as in ordinary graptolites; but I have not been able to determine clearly the existence of a solid axis. The cellules are indicated by angular processes or cell-denticles on the inner side of the branches; as shown in fig. 5 of plate B.

In the genus *Rastrites* of Barrande the distinguishing features are the slender cylindrical stipes or branches, with distant slender tubular cellules.

The few species of *Thamnograptus* known consist of cylindrical or subcylindrical stipes, with slender elongate alternating pinnulæ or branchlets. No evidence of cellules has been observed in any of the specimens.

The peculiar forms for which I have proposed the name *Ptilograptus*, consist of branching stems, which, in all their divisions, are studded on each side, in alternating order, with narrow pinnulæ. These are sometimes extremely slender, or even capillary in their dimensions. In one species I have detected elliptical spots upon one face of the pinnulæ, which are slightly flattened, and I infer that these are the cell-apertures. The substance of the test is corneous, and there is an internal solid axis. Although I have placed these forms under the Graptolitidæ with some hesitation, the form of cellules may perhaps render a separation desirable; but with only our present information, such a separation cannot at this time be made.

The genus *Inocaulis* was proposed for some flattened stipes with a scabrous surface, which have the appearance of denticles upon the margins. These stipes grow in close groups or tufts, and are bifurcating or branched in their upper portions. No positive evidence of cellules has been observed. The presence of denticles, together with a corneous or carbonaceous substance, have induced me to place this fossil among the Graptolitidæ.

There is still another form known, which may be doubtfully classed among the Graptolitidæ. It consists of a slender flexible median rachis, on each side of which are placed, in alternating order, slender flattened pinnulæ, which are of nearly equal width throughout, and are themselves flexuous. Upon one side of the rachis are minute points or dots, which have apparently been the cell-apertures. The test is a black corneous or carbonaceous substance, but there is no evidence of a solid central axis. These bodies are numerous in some shaly beds of the age of the Trenton limestone, at Plattville, Wisconsin. For these I have proposed the name of *Buthograptus*.*

Associated with the preceding forms, there are some stems of corneous or carbonaceous texture, frequently branched, the branches again dividing, and sometimes, if not always, in whorls; in one of which six divisions were counted. The general form of the body is not unlike that of *Dendrograptus*, but the branches are more slender, and ramify in a different manner, while there are no visible cellules. Without farther knowledge,

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* Report of Progress of the Geological Survey of Wisconsin for 1860, p. 19; communicated January 1st, 1861.

I refer these fossils, with hesitation, to the genus *Oldhamia* (*O. fruticosa*, Hall).

The variety of form and mode of development among the graptolites is shown, by these collections from the Quebec group, to be much greater than had ever before been supposed. The number of species which have been traced to their origin, and whose mode of growth has been verified, is probably larger than in all the collections heretofore made; and, together with those before known, enables us to give a very full exposition of the characters of this family of fossils.

SYNOPSIS OF THE GENERA OF GRAPTOLITIDÆ.

I.

Species consisting of stipes or fronds, with a bilateral arrangement of the parts; a solid axis, with a common canal extending along each series of cellules.

1. The successive buds developed in tubular cellules, which are usually in contact for a greater or less proportion of their length, and inclined towards the axis.	
a. Cellules in single series along one side of a common solid axis. Stipes, two or more, from a common origin, with or without a central disc. Sub-genera *Monoprion*,[*] *Didymograptus*, *Monograptus*, *Tetragraptus*, etc.	GRAPTOLITHUS, *Linnæus*.
b. Cellules on one side of slender branches, which are developed on one or two sides of a long slender axis or rachis, the free extremities of which are likewise celluliferous. Ex. *G. gracilis* and *G. divergens*.	
c. Cellules developed in parallel arrangement on two sides of a common solid axis. Stipes narrow elongate. Sub-genus *Diprion*, = *Diplograptus*.	
d. Cellules developed in a cruciform arrangement on the four sides of a common or coalescent axis. Stipes elliptical or sub-elliptical.	PHYLLOGRAPTUS, *Hall*.
2. Cell-apertures excavated in the margins of the stipes, without tubular or cup-form extension; the cell-apertures upon one or both sides of the stipe. *Graptolithus bicornis* and others.	CLIMACOGRAPTUS, *Hall*.
3. Solid axis eccentric or sub-exterior, with cellules developed in parallel ranges on opposite sides of the stipe, and in contact throughout their entire length.	
a. Known only as separate stipes, with reticulate test.	RETIOLITES, *Barrande*.
b. Occurring as simple stipes, and as compound fronds; test smooth.	RETIOGRAPTUS, *Hall*.

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[*] Should it be proved that there exist simple stipes with a single range of cellules, the definition of this section will require to be modified, or a new sub-section made to include such forms.

II.

Species having a common trunk or stem, or growing in sessile groups of stipes from a common origin, without distinct bilateral arrangement of the parts. Cellules in single series on one side of the stipes or branches, and arranged along a common canal or axis.

1. Branches free (i. e. not connected by transverse bars;) cellules in contact or closely arranged.	Dendrograptus, *Hall.*
2. Branches unfrequently and irregularly connected by transverse processes.	Callograptus, *Hall.*
3. Stipes and branches more or less regularly united in a reticulate frond, without elongate stem.	Dictyonema, *Hall.*
4. Stipes round or flattened, growing in groups, and bifurcating above; margins denticulate; surface rough or scaly. [*The relations of this genus are not fully determined.*]	Inocaulis, *Hall.*

III.

Slender cylindrical branches, with tubular cellules arranged in single (or in double ?) series. Cellules not in contact in any part of their length. Rastrites, *Barrande.*

IV.

Species having a common axis or rachis, with slender lateral alternating branchlets. Cellules unknown. Thamnograptus, *Hall.*

V.

Species having a common axis, more or less frequently bifurcating, with pinnulæ closely and alternately arranged on the opposite sides; cell-apertures on one face of the pinnulæ. Ptilograptus, *Hall.*

VI.

A simple flexuous rachis, with slender flexuous flattened pinnulæ arranged in alternating order at close and regular intervals on the two sides. Cell-apertures unknown, or circular. Buthograptus, *Hall.*

VII.

Strong stems, which are numerously branched. Branches and branchlets slender, arranged in whorls. Cellules undetermined. Oldhamia [?], *Forbes.*

§ VII.—GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE GRAPTOLITES IN THE ROCKS OF CANADA AND THE UNITED STATES.

Until the remarkable discovery of the graptolites of Point Lévis in 1854, the chief repository of these fossils known in American rocks was in the shales of the Hudson River valley.

The position assigned to the rocks of the Hudson River valley was the superior part of the lower division of the Silurian system. In this respect, the horizon of the Graptolite beds corresponded with those of Ireland, from which these fossils had been described by General Portlock;* and with the position assigned to those in Sweden, as well as with those of the

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* Geological Report on Londonderry, etc., page 317–322.

Llandeilo and Caradoc formations of Great Britain. The graptolites of Bohemia are from strata referred by M. Barrande to the base of the superior division of the Silurian system; and those of Saxony were regarded as from the same horizon.

In 1850, M. Barrande expressed the opinion that the epoch of the graptolites was posterior to that of the "Faune Primordiale" in Bohemia and Scandinavia; while their association with primordial fossils in the Malvern Hills and at Snowdon, indicated the earlier appearance of these zoophytes in Great Britain. A comparison of all the published information on the subject at that time induced M. Barrande to conclude, as a general fact, that the graptolites had made their earliest appearance in the regions of the northwest; and that their highest development in central Europe had only been reached at a later period, or at the base of the upper division of the Silurian system.

The investigations in the Geological Survey of New-York had proved in a pretty satisfactory manner that no graptolites proper occurred above the horizon of the Clinton group, though *Dictyonema* (supposed to belong to the same family) had been found in the Niagara formation. The species at that time known ranged from the higher strata of the Lower Silurian, to the lower beds of the Upper Silurian division; and both in Europe and America, these fossils were regarded as of eminently Silurian character, and unknown in any later geological periods.

The discovery of a graptolitic species in the Potsdam sandstone of the St. Croix River valley, by Dr. H. A. Prout, in 1850, was the first indication of the occurrence of this family of fossils at a lower horizon than that of the Hudson River and Trenton formations.

Before the discovery of graptolites in the shales of Point Lévis, these rocks were supposed to belong to the age of the Hudson River formation; and although it was shown that the graptolites were all of different species from those previously described, yet they appeared to offer only corroborative evidence in support of the previously entertained opinion regarding the age of the strata. It was only at a later period, and from the discovery of numerous other fossils in the same formation, some of them having a primordial aspect, that its higher antiquity was suspected.

The shales of Point Lévis, with their associated limestones and sandstones, since termed the Quebec group, are now regarded as embracing the period from the Calciferous sandstone to the Chazy limestone, inclusive. This epoch therefore is entirely anterior to that of the Hudson River formation, and a careful comparison of all the species of graptolites has shown that no identical species occur in the two series of rocks.

In the present state of our knowledge, we recognize the Graptolitidæ as beginning their existence at the period of the Potsdam sandstone. The greatest development of the family, both in genera and species, is found to be at the epoch of the Quebec group. Several genera and a few species are known in the Trenton formation; and a greater development, embracing most of the genera and many species, occurs at the period of the Hudson River formation in Canada and the United States. In the Clinton strata we have a single species of *Graptolithus*, and a *Retiolites*; while *Dictyonema* and *Inocaulis* occur in the Niagara beds. In all the subsequent geological formations we have found no true graptolites, and the only representatives of the family consist of fragments of *Dictyonema*, belonging to a few species. These occur in the Upper Helderberg and Hamilton formations, above which we do not yet know a species of any genus referable to this family of fossils. The genus *Graptolithus* has its upper limit in the shales of the Clinton formation, and all others of the family, except *Dictyonema*, are restricted to the Silurian system.

The geographical distribution of the Graptolitidæ is not in all respects coincident with the extent of the geological formations. *Dendrograptus* occurs in the Potsdam sandstone of the St. Croix valley; but neither this nor any other graptolite is known in other localities of the sandstone, so far as I am aware. The species of the Quebec group, numbering more than all the other formations together, have been identified for a longitudinal extent of about 900 miles; Point Lévis, Orleans Island, St. Anne's River (Gaspé), and the western part of Newfoundland, being the principal localities. But although the Quebec group is known to extend into Vermont and along the eastern counties of New-York, I am not aware that graptolites have been found in any authentic localities of that formation.* Thus far, therefore, these fossils of the group are known only in Canada and Newfoundland.

The Trenton limestone, while furnishing two species of *Graptolithus* in New-York, gives at the west no specimens of the genus proper; but we have one *Dictyonema*, a *Buthograptus*, and an *Oldhamia*? in the same formation in Wisconsin, though not elsewhere known.

The Utica slate at Utica abounds in the remains of graptolites, and these fossils are of frequent occurrence at Oxtungo Creek, in the valley of the Mohawk. It is probable that some of the localities referred to the Hudson River formation, may be in the Utica slate, which, owing to the disturbed condition of the strata, is not separable from the succeeding slates.

In the Hudson River formation, the characteristic graptolites, of numerous species, have been found, in greater numbers than elsewhere, at Norman's Kill near Albany; but they occur at Stuyvesant's Landing, and at the city of Hudson; while some species have been found near Baker's Falls on the Hudson River, and at Ballston and Saratoga, New-York. Graptolites of species identical and similar to those of the Hudson River formation have been found by Dr. Emmons in the shales of Augusta County, Virginia, and also in Tennessee.

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* A single branching form, the *G. Milesi*, has been published in the Geological Report of Vermont. The specimen was found in a boulder of slate, but it is probably of the Quebec group.

The more characteristic species of the formation, *G. pristis*, *G. bicornis*, *G. ramosus*, *G. sextans*, *G. divaricatus*, and *G. gracilis*, have been recognized among the collections of the Canada Geological Survey, from the Hudson River formation in the valley of the St. Lawrence. In the extension of this formation westward, a few species only have been found in central and western New-York; among these, *G. pristis* is the most common, while *G. bicornis* is more rarely seen. In Ohio, we have no more than two species from rocks of this formation; while extensive collections from the same formation in Wisconsin and Iowa have afforded only three species (all unlike those from Cincinnati), and one of these has been found in beds of the same age in Illinois. In the catalogue of fossils appended to the Geological Report of Missouri, no mention is made of the occurrence of Graptolitidæ in any of the formations.

The great accumulation of materials at the epoch of the Hudson River formation has been in the direction from northeast to southwest; and along this line the black and dark colored graptolite schists, alternating with coarser beds, have collected in much greater mass than in any other part of its extent. In the northwestern counties of New-York, Jefferson and Oswego, where the formation has a thickness of more than a thousand feet, the graptolites are comparatively few in species, and not of common occurrence. The gradual attenuation of the rocks of this formation towards the west is marked by the extreme paucity of graptolitic forms.

The graptolites of the Clinton strata have not, to my knowledge, been found beyond the limits of western New-York; and both their horizontal and vertical range is very restricted. The graptolitic forms of the Niagara formation (*Dictyonema* and *Inocaulis*) are very limited in their geographical extent.

The *Dictyonema* of the Upper Helderberg and Hamilton formations are known to occur in New-York and in Ohio; and in the northwest a species has been found in the Upper Helderberg limestone on Mackinac Island.

This distribution of the Graptolitidæ, as well as their general association with other fossils, together with the nature of the sediments, would indicate the proximity of the coast-line as their habitat, and as the zone of their greatest development.

TABLE SHOWING THE VERTICAL DISTRIBUTION OF THE GENERA OF THE FAMILY OF GRAPTOLITIDÆ.

GENERA.		Potsdam.	Calciferous, Chazy, } Quebec.	Trenton.	Hudson.	Medina.	Clinton.	Niagara.	Onondaga.	Lower Helderberg.	Upper Helderberg.	Hamilton.	Chemung.	Carboniferous.
GRAPTOLITHUS,	Sub-genus Monoprion	..	*	*	*	..	*	..	..	..	..	..	..	..
	Sub-genus Diplograptus	..	*	*	*	..	..	..	..	..	..	..	..	..
CLIMACOGRAPTUS*		..	*	..	*	..	..	..	..	..	..	..	..	..
PHYLLOGRAPTUS		..	*	..	..	..	..	..	..	..	..	..	..	..
RETIOLITES		..	*	..	..	..	*	..	..	..	..	..	..	..
RETIOGRAPTUS		..	*	..	*	..	..	..	..	..	..	..	..	..
DENDROGRAPTUS		*	*	..	..	..	..	..	..	..	..	..	..	..
CALLOGRAPTUS		..	*	..	..	..	..	..	..	..	..	..	..	..
DICTYONEMA		..	*	..	.	..	..	*	.	..	*	*	..	..
PTILOGRAPTUS		..	*	..	..	..	..	..	..	..	..	..	..	..
THAMNOGRAPTUS		..	*	..	*	..	..	..	..	..	..	..	..	..
RASTRITES		..	..	..	*	..	..	..	..	..	..	..	..	..
INOCAULIS		..	..	..	..	..	..	*	..	..	..	..	..	..
BUTHOGRAPTUS		..	..	*	..	..	..	..	..	..	..	..	..	..
OLDHAMIA ?		..	..	*	..	..	..	..	..	..	..	..	..	..

The pre-eminence of the Quebec group, as the period of the greatest development in the Graptolitidæ, is shown in the above table. Of the fifteen genera and one sub-genus here enumerated, eleven are known in this period; while four genera, viz., *Phyllograptus*, *Dendrograptus*, *Callograptus*, and *Ptilograptus*, are not at present known in any higher position than the Quebec group, though one of them occurs in the Potsdam Sandstone. All those genera having the nearest relations with *Graptolithus* proper occur in this group, and the species of that genus found in it are more numerous than in all the subsequent formations, so far as at present known.

In addition to circumstances originally favorable to their development and growth, the subsequent conditions presented during the period of the Quebec group in Canada seem to have been equally favorable to the preservation of graptolites, and in no other formation have they been found with all their parts so entire.

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* Under this genus, in the following table I have introduced a sub-genus, *Dicranograptus*.

TABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF THE SPECIES OF GRAPTOLITIDÆ IN CANADA AND THE UNITED STATES.

GENERA AND SPECIES.		Potsdam.	Calciferous, Chazy, } Quebec.	Trenton.	Hudson River.	Medina.	Clinton.	Niagara.	Onondaga.	Lower Helderberg.	Upper Helderberg.	Hamilton.	Chemung.	Carboniferous.
Genus GRAPTOLITHUS, Linnæus.														
(Sub-genus MONOPRION, Barrande.)														
G. abnormis,	H.		*											
alatus,	H.		*											
arcuatus,	H.		*											
bifidus,	H.		*											
Bigsbyi,	H.		*											
bryonoides,	H.		*											
Clintonensis,	H						*							
constrictus,	H.		*											
crucifer,	H.		*											
denticulatus,	H.		*											
divergens,	H.				*									
extensus,	H.		*											
extenuatus,	H.		*											
flaccidus,†	H.				*									
flexilis,	H.		*											
fruticosus,	H.		*											
gracilis,	H.				*									
Headi,	H.		*											
indentus,	H		*											
Logani,	H.		*											
Logani, var.,	H.		*											
Milesi,‡	H.		* ?											
multifasciatus,	H.				*									
nitidus,	H.		*											
octobrachiatus,	H.		*											
octonarius,	H.		*											
patulus,	H.		*											
pennatulus,	H		*											
quadribrachiatus,	H.		*											
ramulus,	H.		*											
Richardsoni,	H.		*											
rigidus,	H.		*											
sagittarius,	H. (His. ?)				*									
serratulus,	H.				*									
similis,	H.		*											
tenuis,	H. (P. ?)				*									
(Sub-genus DIPLOGRAPTUS, McCoy.)														
G. amplexicaulis,	H.			*										
angustifolius,	H.				*									
ciliatus,	H.				*									
inutilis,	H.		*											
marcidus,	H.				*									
mucronatus,	H.				*									
peosta,	H.				*									
pristis,	H. (His. ?)				*									
pristiniformis,	H.		*											
putillus, n. s.,	H.				*									

† Utica slate. ‡ From a boulder.

Table showing the Geological Distribution of the Species of Graptolitidæ in Canada and the United States.—(Continued.)

GENERA AND SPECIES.		Potsdam.	Calciferous, Chazy, Quebec.	Trenton.	Hudson River.	Medina.	Clinton.	Niagara.	Onondaga.	Lower Helderberg.	Upper Helderberg.	Hamilton.	Chemung.	Carboniferous.
(Sub-genus DIPLOGRAPTUS, McCoy.)—(Con'd.)														
G. quadrimucronatus, †	H	..	..	..	*	..	..	..	..	..	..	..	..	..
secalinus,	Eaton	..	*	..	..	..	..	..	..	..	..	..	..	..
spinulosus,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
Whitfieldi,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
(unnamed,) n. s.		..	..	..	*	..	..	..	..	..	..	..	..	..
Genus CLIMACOGRAPTUS, Hall.														
C. antennarius,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
bicornis,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
parvus, n. s.,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
typicalis, n. s.,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
(Sub-genus DICRANOGRAPTUS, Hall.)														
C. divaricatus,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
furcatus,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
ramosus,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
sextans,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
Genus PHYLLOGRAPTUS, Hall.														
P. angustifolius,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Anna,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
ilicifolius,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
typus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Genus RETIOLITES, Barrande.														
R. ensiformis,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
venosus,	H	..	..	..	..	..	*	..	..	..	..	..	..	..
Genus RETIOGRAPTUS, Hall.														
R. eucharis, ‡	H	..	..	..	*	..	..	..	..	..	..	..	..	..
Geintzianus,	H	..	..	..	*	..	..	..	..	..	..	..	..	..
tentaculatus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Genus DENDROGRAPTUS, Hall.														
D. diffusus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
divergens,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
erectus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
flexuosus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
fruticosus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
gracilis,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Hallianus,	Prout	*	..	..	..	..	..	..	..	..	..	..	..	..
striatus,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Genus CALLOGRAPTUS, Hall.														
C. elegans,	H	..	*	..	..	..	..	..	..	..	..	..	..	..
Salteri,	H	..	*	..	..	..	..	..	..	..	..	..	..	..

† Utica slate.

‡ Utica slate, Lake St. John.

TABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF THE SPECIES OF GRAPTOLITIDÆ IN CANADA AND THE UNITED STATES.—(Continued.)

GENERA AND SPECIES.		Potsdam.	Calciferous, Chazy, } Quebec.	Trenton.	Hudson River.	Medina.	Clinton.	Niagara.	Onondaga.	Lower Helderberg.	Upper Helderberg.	Hamilton.	Chemung.	Carboniferous.
Genus Dictyonema, Hall.														
D. cadens, n. s.,	H..............	..	..	..	..	..	..	..	..	..	..	*	..	..
fenestrata,	H..............	..	..	..	..	..	..	..	..	..	*	..	..	..
gracilis,	H..............	..	..	..	..	..	..	*	..	..	..	..	..	..
Hamiltoniæ, n. s.,	H..............	..	..	..	..	..	..	..	..	..	..	*	..	..
irregularis,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
Murrayi,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
Neenah,	H..............	..	..	*	..	..	..	..	..	..	..	..	..	..
quadrangularis,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
retiformis,	H..............	..	..	..	..	..	..	*	..	..	..	..	..	..
Websteri,†	H..............	..	..	..	..	..	..	*	..	..	..	..	..	..
Genus Ptilograptus, Hall.														
P. Geinitzianus,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
plumosus,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
Genus Thamnograptus, Hall.														
T. Anna,	H..............	..	*	..	..	..	..	..	..	..	..	..	..	..
capillaris,	H..............	..	..	..	*	..	..	..	..	..	..	..	..	..
typus,	H..............	..	..	..	*	..	..	..	..	..	..	..	..	..
Genus Rastrites, Barrande.														
R. Barrandi,	H..............	..	..	..	*	..	..	..	..	..	..	..	..	..
Genus Buthograptus, Hall.														
B. laxus,	H..............	..	..	*	..	..	..	..	..	..	..	..	..	..
Genus Inocaulis, Hall.														
I. plumulosa,	H..............	..	..	..	..	..	..	*	..	..	..	..	..	..
Genus Oldhamia [?], Forbes.														
O. fruticosa...........	H..............	.	..	*	..	..	..	..	..	..	..	..	..	..

† Nova Scotia.

§ VIII.—HISTORICAL NOTICE[*] OF THE GENUS GRAPTOLITHUS.

Folia gramineum	Bromel.
Graptolithus	Linnæus, Wahlenberg, Beck, Quenstedt, Murchison, Portlock, De Verneuil, Keyserling, Mather, Vanuxem, Emmons, Barrande, D'Orbigny, Geinitz, Suess, Meneghini, McCoy, Richter, Salter, Nicol, Harkness, Hall.
Graptolites	
Priodon	Nilsson.
Orthoceratites	Wahlenberg, Schlotheim, Quenstedt, Geinitz.
Lomatoceras	Bronn, Eichwald.
Prionotus	Nilsson, Hisinger.
Fucoides	Brongniart, Eaton, Emmons, Conrad.
Petalolithus	Suess.
Diprion (sub-genus)	Barrande.
Didymograptus	McCoy, Salter, and others.
Diplograptus	McCoy, Salter, Harkness, etc.
Monoprion (s.-gen.)	Barrande.
Monograptus	Geinitz, Emmons.
Cladograptus	
Glossograptus	Emmons.
Nemagraptus	
Tetragraptus	Salter.
Dichograptus	

A. D. 1727. The graptolites of Sweden were observed by Bromel, who regarded them as leaves of grasses. (*Act. Upsal.*)

1736. Linnæus established the genus *Graptolithus* in the first edition of his *Systema Naturæ;* and some years later, in the twelfth edition, introduced specific names, *G. scalaris* being the type of the genus. This form has been regarded by Wahlenberg, Geinitz, and Barrande as the *G. sagittarius*, compressed in a direction rectangular to the cellules. The *G. sagittarius*, Linn., is therefore regarded by the latter author as the veritable historical prototype of the genus *Graptolithus* and of the family of graptolites. For my own part, I consider the *G. scalaris*, so far as illustrations of that form have come under my observation, as a distinct type of the graptolite family.

1821. Wahlenberg considered the graptolites of Sweden as very slender orthoceratites. (*Nova Acta. Soc. Scien. Upsal*, vol. viii, pp. 92 and 93.)

1822. Schlotheim, participating in the opinion of Wahlenberg, described and figured a species under the name *Orthoceratites serratus.* (*Petrefakenkunde*, p. 56, pl. viii, fig. 3.)

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[*] From the earliest notice of the genus Graptolithus to the year 1850, I have added but little to that which has already been published by M. Barrande in his Graptolites of Bohemia.

1828. Ad. Brongniart described two species of graptolites from the Transition formation at "Pointe Lévi près Québec dans le Canada," as *Fucoides dentatus* and *F. serra.*[*] (*Histoire des Végétaux Fossiles*, pp. 70 and 71, pl. vi, fig. 7–12.)

1829 [1831 ?]. F. Holl republished the description of *Orthoceratites serratus* of Schlotheim. (*Handbuch die Petrefacten.*, vol. ii, p. 234.)

18— ? Prof. Nilsson recognized the graptolites as polyps belonging to the ceratophydians. He proposed to substitute the pre-occupied name of *Priodon* for that of *Graptolithus*. (See *Dr. Beck*, in *Murchison's Silurian System*, p. 696.)

1835. Prof. Bronn, adopting the opinion of Prof. Nilsson regarding the nature of graptolites, gave the name *Lomatoceras* (*Lethea Geognostica*, vol. i, p. 55, pl. i, fig. 13, *L. priodon*), at the same time arranging the species with the orthoceratites, etc.

1837. Hisinger described five species of graptolites from the rocks of Sweden, adopting the generic name *Prionotus*, created by Prof. Nilsson. Among these are two species of Linnæus, *P. sagittarius* and *P. scalaris;* to which he added the new species *P. pristis*, *P. folium*, and *P. convolutus*. (*Leth. Suecia*, p. 113, pl. 35.) In the second supplement to that work, published in 1840, two other species are added, under the names *P. geminus* and *P. teretiusculus;* the latter being of the type of *G. scalaris*. (Supp. ii, p. 5, pl. 38.)

1839. Sir Roderick Murchison described and figured in the Silurian System three species of graptolites, *G. Ludensis*, *G. Murchisoni*, and *G. foliaceus*. (*Sil. System*, p. 695.)

1840. Prof. Eichwald published a description of *Lomatoceras distichus*, a graptolite from the Silurian formation of Esthonia. (*Sil. Syst. in Esthland*, p. 101.)

1840. Prof. Quenstedt sought to re-establish the opinion that the graptolites are true orthoceratites. (*N. Jahrb. f. Min.*, p. 275.)

1842. Prof. Geinitz described and figured five species of graptolites under the names *G. foliaceus*, Murchison, *G. priodon*, Bronn, *G. Ludensis*, Murchison, *G. serratus*, Schloth., *G. scalaris*, Linn., and *G. spiralis*, Geinitz; regarding them as belonging to the Cephalopoda. (*N. Jahrb. f. Min.*, p. 697.)

1842. Vanuxem identified a graptolite of the Utica slate with the *Fucoides dentatus* of Brongniart. *Graptolithus dentatus*, Vanuxem, *G. pristis*, Hall, His.? (*Geol. Rep. 3d Dist. N. Y.*, p. 57, fig. 2.)

1843. Gen. Portlock, in his Geological Report, discussed the nature of the graptolites, recognizing them as true zoophytes, and indicating their analogy with Sertularia and Plumularia. He suggested that the species may form several genera, belonging perhaps to different orders. The species described and enumerated by this author are indicated under the names *G. Sedgwicki*, *G. distans*, *G. tenuis*, Portlock; *G. convolutus*, *G. sagittarius*, *G. pristis*, and *G. folium*, Hisinger; *G. scalaris*, Linn., *G. foliaceus*, Lons. (*Geol. Rep. on Londonderry, Tyrone, and Fermanagh*, pp. 317–321, pls. xix and xx.) The species described by this author as Gorgonia, probably belong to Dictyonema.

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[*] These species are probably identical with those which I have heretofore described as *G. pristiniformis* and *G. bryonoides*.

1843. W. W. Mather and E. Emmons recognized *Graptolithus dentatus* as characterizing the Utica slate. (*Geol. Rep. 1st Dist. N. Y.*, p. 390, *and Geol. 2nd Dist. N. Y.*, p. 279.)

1843. J. Hall described *Graptolithus Clintonensis*, from the shales of the Clinton group in the Upper Silurian. (*Geol. Rep. 4th Dist. N. Y.*, p. 72, fig. 12.)

1845. Sir R. I. Murchison, De Verneuil, and Count Keyserling enumerated *G. sagittarius*, Hisinger, and *G. distichus*, Eichwald, as characterizing the Silurian formations of Russia. (*Geol. of Russia and the Ural Mts.*, vol. ii, p. 382.)

1846. Prof. Geinitz repeats the opinion expressed by himself in 1842, regarding the nature of the graptolites; and divides them into two sections, the straight and the spiral forms. In the first section he describes four species: 1. *G. foliaceus*, Murchison, (with which he identifies *G. pristis* and *G. folium*, Hisinger, and *G. dentatus*, Vanuxem); 2. *G. priodon*, Bronn, (under which he includes *G. Ludensis*, Murchison, and *G. teretiusculus*, Hisinger); 3. *G. sagittarius* and *G. scalaris*, Linn. (which he regards as varieties of the same species), *Fucoides serra*, Brong., and *G. Murchisoni*, Beck; 4. *G. serratus*, Schlot. (*Grundriss der Verstein*, p. 310, pl. x.)

1846. E. Emmons published *Fucoides simplex* [= *Graptolithus secalinus*], from the roofing-slates of Hoosic. (*Natural History of New-York, Agriculture*, vol. i, pl. xvii, fig. 1.)

1847. J. Hall described and figured fifteen species of graptolites, mostly new, from the Lower Silurian strata, placing them among zoophytes. (*Pal. N. York*, vol. i, p. 265, pls. lxxii, lxxiii, and lxxiv.)

1848. Rev. Prof. Sedgwick announced the occurrence of *Graptolithus sagittarius*, His., and *G. latus*, McCoy, in the Skiddaw slates. (*Quarterly Jour. Geol. Soc.*, vol. iv, p. 223.)

1848. J. W. Salter described *G. folium*, *G. pristis*, Hisinger, *G. pristis*, var. *foliaceus*, Portlock, *G. ramosus*, Hall, *G. Tænia*, Sowerby and Salter, *G. tenuis*, Portlock, and *G. sextans*, Hall, from the slates of Loch Ryan, etc. (*Quart. Jour. Geol. Soc.*, vol. v, pp. 15–17.)

1848. Prof. Philips enumerated the *G. Ludensis*, *G. Murchisoni*, and three other species in the Builth, Llandeilo, and Haverford-west districts. (*Memoirs of the Geol. Survey*, vol. ii, part 1, p. 308.)

1849. James Nicol enumerated and described *Graptolithus Griestonensis*, *G. convolutus*, *G. Ludensis*, and *G. laxus*. (*Quarterly Jour. Geol. Soc.*, vol. vi, pp. 63 and 64.)

1849. J. Hall stated the occurrence of twenty species of graptolites in the Lower Silurian rocks; two other species having been found in the Clinton formation.* (*Proceedings of the Amer. Assoc. for the Advancement of Science*, 1849, p. 351.)

1850. J. Barrande published a memoir upon the graptolites of Bohemia, describing seventeen species of *Graptolithus*, of which fifteen were new; a new genus, *Rastrites*, with four species; and the genus *Retiolites*, with one species. These are all placed among the Polypi. All of these species, except one, are found in the Upper Silurian; four of them occur in the colonies of the inferior division, and pass upward to the superior beds; while one species is restricted to the lower division. M. Barrande has given in this memoir a resumé of the geographical and geological distribution of the graptolites in the different countries of the globe.

1850. Prof. McCoy described three species of graptolites, proposing the name *Diplograpsus* for those with a double series of cellules. He proposed also the generic name *Protovirgularia* for a zoophyte which he refers to the Gorgoniadæ, but which may perhaps belong to the Graptolitidæ. (*Annals and Magazine of Nat. Hist.*, vol. vi, 2nd series, pp. 270–272.)

1850. Prof. Harkness described the graptolites found in the black shales of Dumfries-shire, recognizing two species of *Rastrites* and ten species of Graptolites. (*Quar. Jour. Geol. Soc.*, vol. vii, pp. 59–65, pl. i.)

1851. Prof. McCoy published descriptions and figures of graptolites from British palæozoic rocks, adopting the name *Diplograpsus* for the species with two ranges of cellules. Of fifteen species which he described, eleven are identified as those of preceding authors, and three of these are recognized as American species. (*British Palæozoic Fossils*, pp. 3–9, pl. 1 B.)

1851. Dr. H. A. Prout described a graptolite, *G. Hallianus* [= *Dendrograptus*], from the Potsdam sandstone of the St. Croix River. (*Am. Journal Science* [2], vol. ix, p. 187.)

1851. Edward Suess published descriptions of Bohemian graptolites, reproducing nearly all of those described by Barrande, recognizing several other known species, and describing nine new species. He proposed the name *Petalolithus* as a substitute for *Diprion*, = *Diplograptus*. (*Natur-*

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* This number of twenty species included some forms known, but not at that time described.

wissenschaftliche Abhandlungen, vierter Band, pp. 88–184, pls. vii, viii, and ix.)

1851. J. W. Salter described *G. tenuis*, Portlock, and *G. bullatus*, = *G. pristis* ?, from the Silurian rocks of Scotland. (*Murchison*, *Silurian Rocks of Scotland*, *Quart. Jour. Geol. Soc.*, vol. vii, pp. 173 and 174.)

1851. Boeck; *Bemarkinger Angaaende Graptolithen Christiania* (cited by Geinitz; the work not seen by the writer).

1851. Scharenberg, *über Graptolithen* (cited by Geinitz; work not seen by the writer).

1852. Prof. Geinitz described the graptolites of Saxony, placing them among zoophytes, and proposing the genera *Monograpsus* and *Cladograpsus* for certain forms of graptolites, and the genus *Nereograpsus* to include *Myrianites*, *Nereites*, etc. He enumerates and describes fifty species of graptolites of his own, or of preceding authors; and one species of *Retiolites*, *R. Geinitzianus*. (*Die Versteinerungen der Grauwacken-formation*, heft i, *Die Graptolithen.*)

1852. J.W. Salter described some graptolites from the south of Scotland, recognizing three species. (*Quar. Jour. Geol. Soc.*, vol. viii, pp. 388–391, pl. xxi.)

1852. J. Hall reproduced the *Graptolithus Clintonensis*, and described *G. venosus*, = *Retiolites venosus*. He also described the genus *Dictyonema*, suggesting its relations with *Graptolithus*, and likewise the genus *Inocaulis*. (*Palæontology of New-York*, vol. ii, pp. 39 and 40, pl. xvii, and pp. 174–176, plates xl F, and xl G.)

1853. J. W. Salter. A new species of graptolite (*Didymograptus caduceus*, Salter), "from the Lauzon Precipice, Hudson River Group." (*Quarterly Jour. Geol. Soc.*, vol. ix, p. 87.)

1855. Dr. Emmons described several new species of Graptolites, and proposed the generic names of *Nemagrapsus*, *Glossograpsus*, and *Staurograpsus*. (*American Geology*, vol. i.)

1857. Prof. Meneghini, from collections made by General De la Marmora, described ten species of graptolites from the Silurian rocks of the Island of Sardinia, of which eight species were new. (*Palæontologie de l'Ile de Sardaigne.*)

1857. J. Hall communicated to Sir William E. Logan descriptions of twenty-one new species of graptolites from the Lower Silurian rocks of Point Lévis (Lauzon seigniory) near Quebec, (many of the species having compound forms not before known among this family of fossils,) and proposed several new genera. (*Report of Progress*, *Geol. Survey of Canada*, 1857. See also the *Canadian Naturalist and Geologist*, vol. iii.)

1859. J. Hall published *Notes upon the genus Graptolithus*, with an enumeration of the Canadian species; a notice of graptolite-stipes with reproductive cells, together with descriptions of two new species. (*Twelfth Report on the State Cabinet*, Albany, pp. 45 and 58, 1859.)

1859. The preceding notes were reproduced, with descriptions of five additional species of *Graptolithus*, one *Retiograptus*, the genus *Thamnograptus* with two species, and one species of *Rastrites*. (*Palæontology N. Y.*, vol. iii, pp. 495 and 522.)

1860. J. Hall, in continuation of the paper from the Twelfth Report on the State Cabinet (from *Palæontology of New-York*, vol. iii, Supp.), described additional species of *Graptolithus*, *Retiograptus*, *Thamnograptus*, and *Rastrites* as above. (*Thirteenth Report of the State Cabinet*, pp. 55–64, 1860.)

1861. J. W. Salter in "New Fossils from the Skiddaw Slates," noticed the occurrence of several species of *Graptolithus*, and the discovery of a branching form similar to those which Sir William E. Logan first brought to light in Canada, which he proposed to term *Dichograptus*. (*Geologist*, vol. i, p. 74.)

1861. Prof. McCoy sent to the writer a proof of a plate of graptolites from the "*Palæontology of Victoria*." Among the figures are species closely resembling or identical with *G. ramosus*, *G. furcatus*, and *G. gracilis;* while others resemble *G. pristis*, *G. sagittarius*, &c. The descriptions or farther illustrations have not come under our notice.

1861. E. Billings "On the occurrence of Graptolites in the base of the Lower Silurian." The paper contained a review of the work of Freidrich Schmidt, and a comparison of the graptolitic zones in Europe and America, with a view to show that the graptolite-schists of Norman's Kill near Albany are not in the upper part of the Lower Silurian division. (*Canadian Naturalist and Geologist*, vol. vi, pp. 344 and 348.)

1863. Sir William E. Logan recognized the occurrence of *Graptolithus bicornis*, *G. ramosus*, *G. mucronatus*, and *G. pristis*, characteristic species of the shales of Norman's Kill, in the Utica and Hudson River formations of Canada. (*Geology of Canada*, p. 200, and Catalogue of Fossils, p. 942. *Idem*, Graptolites of the Quebec group, pp. 226 and 228.)

1863. J. W. Salter (Note on Skiddaw-Slate Fossils) noticed some new species of graptolites, proposing the new genus *Tetragraptus*, and describing the genus *Dichograptus* previously proposed and cited above. (*Quarterly Journal of the Geological Society*, vol. xix, pp. 135–140, with illustrations.)

⁂ The *Graptolithus* from the Hoosic slate-quarries was named by Prof. Eaton *Fucoides secalinus*, and the specimens were thus labelled in the cabinet of the Rensselaer School at Albany, as known to the writer from 1832 to 1836; but we have been unable to find any published description.

CHAPTER II.

I.—SYNOPSIS OF THE SPECIES OF GRAPTOLITIDÆ OF THE QUEBEC GROUP, DESCRIBED IN THIS MEMOIR.

A. SPECIES HAVING A BILATERAL ARRANGEMENT OF PARTS. (Sub-genus *Monoprion*, Barrande; *Monograptus*, Geinitz.)

Genus GRAPTOLITHUS, Linnæus.

a. Species consisting of two stipes from a single axis. (*Didymograptus*, McCoy; *Cladograptus*, Geinitz in part.)

	Plate.	Figure.
G. nitidus	1	1– 9
patulus	1	10–15
bifidus	1	16–18
bifidus	3	9–10
indentus	1	20
extenuatus	1	21–22
constrictus	1	23–27
similis	2	1– 5
arcuatus	2	6–10
extensus	2	11–16
pennatulus	3	1– 8
pennatulus	5	9

b. Species consisting of four simple stipes from a single axis, with or without a central disc. (*Tetragraptus*, Salter. *Dichograptus*, Salter, in part.)

	Plate.	Figure.
G. bryonoides ?	3	11–12
bryonoides	4	1–11
bryonoides	6	4
denticulatus	4	12–16
quadribrachiatus	5	1– 5
quadribrachiatus	6	5– 6
fruticosus	5	6– 8
fruticosus	6	1– 3
crucifer	5	10
Headi	6	8
alatus	6	9
Bigsbyi	16	22–30

c. Species consisting of eight simple stipes proceeding from a single axis, with or without a central disc. (*Dichograptus*, Salter, in part.)

	Plate.		Figure.
G. octobrachiatus	7	....	1–7
octobrachiatus	8	....	1–4
octonarius	10	....	1, 2

d. Species consisting of more than eight simple stipes proceeding from a single axis, with a distinct broad corneous disc. (*Dichograptus*, Salter, in part.)

	Plate.		Figure.
G. Logani	9	....	1–9
Logani, var.	11	....	7

e. Species with the stipes proceeding from a single axis, and more or less frequently branched during their entire length; not known to have a central disc.

	Plate.		Figure.
G. flexilis	10	....	3–9
rigidus	11	....	1–5
abnormis	11	....	6
Richardsoni	12	....	1–8
ramulus	12	....	9,10

B. SPECIES (so far as known) CONSISTING OF SIMPLE STIPES WHICH ARE CELLULIFEROUS ON TWO SIDES.

a. Cellules tubular, inclined to the axis, aperture subquadrangular.

	Plate.		Figure.
G. (Diplograptus) pristiniformis	13	....	15–17
" inutilis	13	....	14

b. Cellules short and square, aperture transversely-elliptical, apparently excavated in the margin of the stipe.

Genus CLIMACOGRAPTUS, Hall.

	Plate.		Figure.
C. antennarius	13	....	11–13

Genus RETIOLITES, Barrande.

	Plate.		Figure.
R. ensiformis	14	....	1– 5

C. SPECIES WITH NUMEROUS SIMPLE STIPES FROM A SINGLE AXIS, IN BILATERAL ARRANGEMENT. (Other species known only as simple stipes.) (Sub-genus *Diprion*, Barrande; *Diplograptus*, McCoy.)

Genus RETIOGRAPTUS, Hall.

	Plate.	Figure.
R. tentaculatus	14	6–8

D. SIMPLE STIPES WITH QUADRILATERAL ARRANGEMENT OF PARTS.

Genus PHYLLOGRAPTUS, Hall.

	Plate.	Figure.
P. typus	15	1–12
ilicifolius	16	1–10
Anna	16	11–16
angustifolius	16	17–21

E. SPECIES HAVING STEM-LIKE AXES WITH NUMEROUS IRREGULAR RAMIFICATIONS.

Genus DENDROGRAPTUS, Hall.

	Plate.	Figure.
D. flexuosus	17	1–2
flexuosus?	18	4
divergens	17	3, 4
striatus	17	5, 6
erectus	17	7
fruticosus	17	8, 9
diffusus	18	1–3
gracilis	18	5, 6

F. SPECIES WITH FLABELLATE OR FUNNEL-SHAPED FRONDS, THE BRANCHES OF WHICH ARE CONNECTED BY REGULAR DISSEPIMENTS GIVING A FENESTRATE STRUCTURE, OR BY UNFREQUENT AND IRREGULAR TRANSVERSE BARS, AND SOMETIMES BY AN ANASTOMOSING OF THE ADJACENT PARTS OF THE BRANCHES.

Genus CALLOGRAPTUS, Hall.

	Plate.	Figure.
C. elegans	19	1–4
Salteri	19	5–8

Genus DICTYONEMA, Hall. (GRAPTOPORA, Salter.)

	Plate.	Figure.
D. irregularis	20	1, 2
robusta	20	3, 4
quadrangularis	20	5
Murrayi	20	6, 7

G. SPECIES CONSISTING OF BRANCHES WITH SUB-CYLINDRICAL OR ROUNDED AXES; THE ULTIMATE PINNULÆ ELONGATE, SETIFORM, OR PLUMOSE, AND ALTERNATELY ARRANGED ON THE TWO SIDES OF THE AXIS OR LARGER RAMUS.

Genus PTILOGRAPTUS, Hall.

	Plate.	Figure.
P. plumosus	21	1–4
Geinitzianus	21	5–8

Genus THAMNOGRAPTUS, Hall.

Thamnograptus Anna	21	9

SPECIES INTRODUCED FROM THE UTICA SLATE OF LAKE ST. JOHN, FOR COMPARISON AND ILLUSTRATION.

GRAPTOLITHUS.

	Plate.	Figure.
G. (= Monoprion = Didymograptus) flaccidus	2	17–19
G. (= Diplograptus) quadrimucronatus	13	1–10

RETIOGRAPTUS.

	Plate.	Figure.
Retiograptus eucharis	14	9

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§ II.—DESCRIPTIONS OF THE SPECIES OF GRAPTOLITIDÆ FIGURED IN THIS MEMOIR.

GENUS GRAPTOLITHUS, Linnæus.

Generic Characters.—Polypidom or frond consisting of slender elongated stipes or stems, which are flattened and quadrangular, and may be simple or compound, and sometimes bifurcating. The cellules take their origin from a common body or canal, which is parallel to a slender axis.

Some of the species have the cellules in single series, and others have them in two series, arranged on opposite sides of the stipe.

Those species with the single series of cellules (*Monoprion*, = *Monograptus*) have the axis marginal; while those with the two series of cellules (*Diprion*, = *Diplograptus*) have each series entirely independant of the other and separated by a double solid axis, leaving no communication between the series, each of which has its common body or canal, as in those with the single series of cellules. This character is clearly shown in some of the bi-celluliferous species, which subdivide above the base by the dehiscence of the axes.

The species having a single series of cellules are developed in a bilateral arrangement of the parts on the two sides of a central point or radicle. The simplest forms known consist of two single elongate stipes; others have four, eight, or more simple stipes; while in other species the stipes are variously bifurcated; but in all they are symmetrically and bilaterally arranged upon the two sides of the specimen. Many of these compound forms have the bases of the stipes united in a central corneous disc or cup, which is of the same substance as the stipes, thickened in the middle, and attenuate at the margins, and which in the living condition was probably of a concavo-convex form.

The centre of these discs on the exterior side often presents a small prominence or point, which however does not bear evidence of having been attached, at least during the later periods of the animal's life.

The species under this genus may for convenience be distributed in two sections with several subordinate divisions, as shown on pp. 65 and 66.

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1. GRAPTOLITHUS NITIDUS, Hall.

Plate I, figures 1–9.

(G. NITIDUS, Hall: *Geological Survey of Canada*, Report for 1857, page 129.)

Description.—Frond composed of two simple stipes proceeding from a small radicle, and diverging at an angle of about 175°. Stipes narrower at the base, and gradually widening towards the extremities, which in perfect specimens are somewhat rounded from the partial development of two or three of the terminal cellules. Radicle short, abruptly tapering to a slender point. The stipes in their greatest width are from six to ten hundredths of an inch, while near the base they are often not more than five hundredths of an inch in width. The proportion of the stipe occupied by the common body is about one sixth, or less than one sixth of the entire width. In the broader stipes, the limits marked by the pustuliform elevations indicate the bases of the cellules. In some specimens, one fourth of the width is occupied by the common body.

Cellules long and narrow, from thirty-two to thirty-four in the space of an inch, curving slightly upwards, nearly twice as large at the aperture as at the base, and about three times as long as their greatest width when the stipe is flattened; inclined to the axis at an angle of from 35° to 45°; division-walls of cellules in contact, or united for three fourths of their entire length; margin of the aperture straight, or slightly curved near the anterior edge, making an angle of 110° or 112° with the axis; the anterior margin, in the broader stipes, lies over the base of the third cellule in advance. The limits of the cellules are strongly marked by a line indicating the place of the partition or divisional cell-wall, which on one side often terminates below in a pustule.

This beautiful little species differs very distinctly from all others of the genus which I have studied; and it bears little relation to any of the European forms described, so far as they have come under my observation. The substance of the stipe is usually thickened, brownish-black in color, smooth or slightly wrinkled from desiccation, and rarely marked with distinct striæ parallel to the cell-margins. The striæ apparently indicate the successive stages of growth or development of the cell-walls. The divisions between the cellules are strongly marked by what usually appears to be a distinct groove produced by the folding of one cell over the other at the line of junction, this line indicating the place of the cell-partition. The sheath or common body of this species is usually partially filled with stony matter, and a section presents an extremely elongated oval form. This condition may be partly due to the original character of the body, or to the nature of the matrix; which is less finely laminated than some of the graptolitic slates, but preserves the fossil in a very beautiful manner. The imprints are stained by oxide of iron, and the striæ marking the divisions of the cellules are often well preserved. The transverse striæ parallel to the apertures of the cells are often distinctly seen in casts of the interior.

The minute tubercles marking one side of the stipe are rarely shown on the two sides, and sometimes on neither side. The conditions of pressure may have had some influence in causing this appearance; since the point of the abrupt bending of the partition between the two cellules may have resisted more than the other parts, and thus produced the prominence observed. The proportions of parts are subject to slight variations, dependent mainly on the degree of stipe-development. In the narrower forms, the cell-aperture often lies vertically above the base of the second cellule in advance, instead of above that of the third as in the wider forms. In the relations of the cellules to each other, they appear as if the pressure had been exerted obliquely to the direction of the axis; the cellules being slightly *en échélon.* There are however many indications pointing to such an arrangement as being the original disposition of the cellules on the axis, not only in this but in other species.

The impressions of *G. bryonoides* resemble those of this species; but the stipes are broader, the striæ less rigid and distinct, and the tubercles and coarser denticles of *G. nitidus* are absent. In mode of growth and general aspect, this species resembles *G. serratulus* of the Hudson River group (Pal. N. Y., vol. 1, p. 274, pl. lxxiv, fig. 5 *a*, *b*); but in the latter the denticles are coarser and more oblique, the lower side being much the longer, and the stipes are more distinctly linear; while in *G. nitidus* the stipes become gradually wider from the base, and are very distinctly striate and pustulose in well-preserved specimens.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS NITIDUS, Hall.

PLATE I.

1. A young individual preserving the radicle and the two stipes.
2. The extremity of a stipe enlarged, showing the partially-developed cellules.
3. A larger specimen of similar character to fig. 1, showing the pustules at the base of the cellules. The extremities are not quite entire.
4. A part of the left side of fig. 3 enlarged, showing the pustuliform elevations.
5. An enlargement from another specimen, with the cellules obliquely compressed, and the pustules obscurely shown.
6. Two smaller individuals, which, from juxtaposition, similarity of size, etc., seem as if they may have originated from a common base.
7. An impression of a more extended form, which is proportionally narrower than fig. 3.
8. A still narrower form of stipe, diverging almost rectangularly from the direction of the radicle.
9. A well-preserved small individual, enlarged three diameters.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

2. GRAPTOLITHUS PATULUS, Hall.

Plate I, figures 10–15.

(G. PATULUS, Hall: *Geological Survey of Canada*, Report for 1857, page 131.)

Description.—Frond composed of two simple stipes diverging almost rectangularly from a small radicle. Stipes long, linear, widening very gradually from the base to the extremities, which are somewhat rounded from the immaturity of the later cellules. Width from base of serratures to the back of the stipe, from one sixteenth to one twelfth of an inch. Surface strongly striate in the direction of the cellules; striæ curving. Radicle minute. The proportion of the stipe occupied by the common body varies from a perceptible line to one fifth of the entire width, and is dependent partly or entirely on the direction of the pressure.

Cellules distinctly limited by the partition-walls, about from twenty-four to twenty-six in the space of an inch; rather wide, making an angle of about 60° with the direction of the axis, and slightly curving upwards; their proportions vary according to the width of the stipe, being from three to four times as long as wide. Outline of the aperture curved, concave, making an angle with the axis of about 130°; on the lower or posterior side produced into mucronate points which curve gently forward: walls of the cellules distinctly striated parallel to their margins, for one half the depth. The anterior margin of each cellule is vertically above the base of the second cellule in advance.

Fragments of this species are numerous upon some slabs of greenish or blackish-green slate where other species occur. The remains of single stipes are sometimes four or five inches in length, showing in different individuals little variation in width after becoming perfectly developed, which occurs within an inch of the radicle. Sometimes the stipes are compressed vertically, and present the smooth linear base or exterior, which is less in width than when compressed laterally. The lateral faces of the stipes exhibit some variety of surface, dependent on the degree of compression, or in some instances, on the replacement or filling of the interior by iron pyrites. In these cases, or when the branch is not flattened, the surface is deeply striated or wrinkled obliquely. Sometimes when extremely compressed, the surface has an appearance of vesicular structure, which is probably due to influences attending the mineralization of the fossil, or the filling up of the original canal.

This species is palpably different from the last in the greater extent of the stipes, and in their almost perfectly linear character. The form of the denticles, and their angle with the axis, as well as their proportional distance, are distinctive characters. The *G. virgulatus* of Beck (Geinitz's Graptolithen, page 37, pl. v, fig. 36) bears some resemblance to this species in the figure of natural size; but our species does not correspond with the enlarged figures.

Explanations of Figures of Graptolithus patulus, Hall.

Plate I.

10. A specimen preserving the radicle, and a stipe on one side two and a half inches in length.
11. The distal extremity of a larger stipe. Some of the cells are filled with iron pyrites.
12. A short stipe broken off near the radicle, showing the narrow form near the base, and a greater width beyond, exceeding that of the ordinary forms.
13. A part of fig. 12 enlarged.
14. A part still further enlarged to show the striæ parallel to the cell-apertures.
15. An enlargement from fig. 11, where some cells are filled with iron pyrites, showing their extension almost to the back of the stipe.

Formation and Locality.—Shales of the Quebec group; from loose masses below the village of Point Lévis.

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3. Graptolithus bifidus, Hall. (n. s.)

Plate I, figures 16–18; Plate III, figures 9, 10.

Description.—Frond two-stiped: stipes diverging from the small short radicle, and curving slightly inward, and thence extending in right lines including an angle of from 15° to 20°, varied by growth or accident. Stipes very narrow, rounded at the base, and gradually expanding above, attaining their greatest width at about two thirds of the distance from the base, from which they are gradually narrowed to the extremity; they curve on the celluliferous margin, and are essentially straight on the back. The cellules continuing to increase in length as the stipe is extended to the point of greatest width, give the peculiar curving outline to the celluliferous margin. In the stipes of ordinary width, about one sixth of the space is occupied by the common body; though this proportion varies with the development of the stipe. Test thin, nearly smooth, or with faint striæ parallel to the cell-margins: divisions between the cellules strongly marked, and frequently terminating below in a minute pustule. The width of stipe varies from one fifteenth of an inch at the base, to one eighth or even one fourth of an inch in the widest portions. Cellules long and slender, except a few at the base, and some partially developed near the apex: the length of the cellules is from three to four and a half times their width, according to the degree of development, and they incline to the axis at an angle of 48° near the lower part, curving more directly upwards in the middle, or more fully developed part of the stipe. Near the base of the stipe the angle of the cellules is greater, and towards the apex it is less, until the last few are inclined at a very low angle. The cellules are free for from one fourth to one third of their length. The apex is extended in a sub-mucronate point. The curving of the cell-margin forms an angle of about 120° with the axis in the widest part of well-developed stipes.

This species is very peculiar, differing from all others described in this memoir (except *G. pennatulus*) in the great inequality of width in the stipe, and the apparently continuous increase of width from the extension of the cellules; while the younger cellules near the apex seem to be slowly developed. The stipe at the base is nearly round. Of the earlier cellules usually four or five and sometimes six or seven do not attain the full proportions. In several specimens (and indeed in all those upon which the species was originally founded), the stipes diverge from the radicle at an angle of 15° or 20° with the celluliferous faces on the inner or approximate margins. A later examination of other collections shows some specimens where the divergence is greater, and the development of parts more excessive.

Three individuals of this species from the shales at Point Lévis preserve very constant characters in the mode of growth and structural details. One, a single stipe much longer than the others from the same locality, presents some departure from the prevailing characters, and is referred with hesitation to this species. Another specimen among later collections from above the river St. Anne, has more divergent stipes and a stronger form than those first described. In the imperfect condition of preservation of these specimens, it is not easy to determine what extent of variation in individuals of this form may be due to the mode of growth and to other causes.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS BIFIDUS, Hall.

PLATE I.

16. A small specimen from the same fragment of slate with fig. 17.
17. An individual of ordinary size.
18. An enlargement of the upper part of one stipe of fig. 17.

PLATE III.

9. An individual of this species, having a greater divergence of the stipes than is usually observed.
10. An enlargement from one of the stipes of the preceding, showing the form of serratures, and the minute pustules at the base of the cell-divisions.

Formation and Localities.—Shales of the Quebec group; Point Lévis, and three miles above the river St. Anne.

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4. GRAPTOLITHUS INDENTUS, Hall.

Plate I, figure 20.

(GRAPTOLITHUS INDENTUS, Hall: *Geological Survey of Canada*, Report for 1857, *page* 128.)

Description.—Frond consisting of two simple stipes, diverging at the base from a slender radicle, and making an angle between the two of 50° for the first quarter of an inch, and above this continuing in a nearly parallel direction. Test somewhat rough: width of stipe about six hundredths of an inch; the back marked by a strong axis, and a scarcely appreciable portion occupied by the common body. Cellules narrow, distant, about twenty in the space of an inch; each one having a length of about three times its width, half of the length being free; inclined at an angle of about 33° to the axis: aperture at right angles to the axis; the apex acute and pointed.

This species bears a resemblance to *G. extenuatus* in the width of stipe and proportional distance of cellules; but the angle of inclination of the cellules and the form of aperture are quite different; the absence of pustules at the base of the cell-divisions is also a very distinctive character. The stipes of this species bear a very close resemblance to those of *G. quadribrachiatus;* but the individual figured, in which the base is preserved, shows in its peculiar curving and smaller serratures near the base, a feature which belongs only to the two-stiped forms. The cellules also appear to be narrower, and are slightly closer in their arrangement; stipes of the same size of the two species, showing respectively eighteen and twenty cellules in equal spaces.

EXPLANATION OF FIGURE OF GRAPTOLITHUS INDENTUS, Hall.

PLATE I.

20. An individual of the natural size, the continuation of the stipes having been broken off.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

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5. GRAPTOLITHUS EXTENUATUS, Hall. (n. s.)

Plate I, figures 21, 22.

Description.—Stipe slender, linear, straight; substance smooth, except the striæ indicating the cell-partitions; width a little less than one twentieth of an inch, the common body occupying a little more than one quarter of the width. The back of the stipe is marked by a strong marginal axis. Radicle unknown.

Cellules narrow, very gradually expanding from the base, length about three and a half times the width; making an angle with the axis of nearly 20°, and curved near the base. Apertures truncate, slightly curved towards the anterior margin, and nearly at right angles with the axis; free for about two fifths of their length; about twenty-four in the space of an inch. The apex of the cell-denticle or aperture is a little forward of the tubercle marking the base of the second cell in advance. The cell-partitions or septa are not strongly marked, but distinct under a lens, and terminate below in a minute rounded process or pustule.

(The specimen on which this description is founded is a fragment of two and a half inches long. Other fragments on the same piece of weathered shale appear to be identical with it, but are too obscure for satisfactory determination. It is supposed to be a bibrachiate form.)

This species bears considerable resemblance to the figure of *G. tenuis* of Portlock, as given by McCoy (Brit. Palæozoic Fossils, pl. i. B, fig. 4 a, b); but the stipe of that one shows no pustule at the base of the cell-division. The original figures of Portlock do not however correspond so nearly with our species in its cellules, while the axis is not so strongly developed. Compared with any of the Canadian forms, except *G. extensus*, it is proportionally narrower; with that one it corresponds in the number of serratures in the same space; but the angle made by the cellules with the axis is very different, and the presence of pustules is a distinguishing feature. From all other analogous forms, this one varies in the form, proportional number, and inclination of the cellules.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS EXTENUATUS, Hall.

PLATE I.

21. A fragment of the stipe, natural size.
22. A portion of the lower extremity enlarged; a part of the specimen retaining the substance of the fossil, and a part being an impression in the slate.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

6. GRAPTOLITHUS CONSTRICTUS, Hall. (n. s.)

Plate I, figures 23–27.

Description.—Frond composed of two slender stipes, which diverge almost rectangularly from a minute radicle, or are usually bent a little backwards, a feature which is more conspicuous in young individuals. The stipes attain their full dimensions near the radicle, maintaining nearly an equal width throughout their length: the extremities are somewhat rounded from the partial development of some of the terminal cellules. The stipes in their greatest width are about nine hundredths of an inch, and vary from five to nine hundredths in their different stages of growth and development. The common body occupies a very small proportion of the entire width, and its limits are not distinctly defined. Surface of stipes quite smooth ; test very thin, and cell-walls usually obscurely marked.

Cellules of moderate length, from twenty-four to twenty-six in the space of an inch, and inclined to the axis at an angle of about 32°, as indicated by the lines of the cell-partitions : line of the aperture truncate, or very slightly convex, making an angle of 120° with the axis, and nearly rectangular to the direction of the cellule. The cellules, in their lower part, and for two thirds of their length, are straight, and scarcely wider throughout than at their origin : at this point, just before becoming free, they are abruptly expanded on the posterior side, and this margin of the free extremity makes a larger angle with the direction of the axis. This expansion of the cellule is perhaps as properly a sudden constriction just below the orifice, or at the base of the cell-denticle. The cell-denticles, under a strong lens, are seen to be finely striated parallel to the line of the aperture.

This species in its mode of growth and general form resembles *G. patulus*, but in its development it earlier attains the full width of the stipe. It is always smoother on the exterior surface, and the cell-walls rarely make distinct striæ, as in that species, though this character is visible under a lens. The form of the denticles is however very characteristic ; and this at once distinguishes it not only from *G. patulus*, but also from every other species of this group. It is associated in the same slates with *G. patulus* and *G. quadribrachiatus*.

A specimen in the shales of Gros Maule, preserving all the essential features of this species, has apparently a thicker test, and the interior is partially filled with stony matter, so that the parts are more clearly seen. In this one the cells show a very gradual expansion towards the aperture, and a slight curvature of the cell-partitions near the base, while the constriction below the cell-mouths is more strongly pronounced.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS CONSTRICTUS, Hall.

PLATE I.

23. A young individual of the natural size.
24. An older specimen.
25. A part of a much more extended stipe, but which is not wider than fig. 23.
26. A part of a stipe from Gros Maule.
27. An enlargement showing the form of cells, the cell-denticles or apertures, and the characteristic apparent constriction.

Formation and Localities.—Shales of the Quebec group ; from some loose masses below the village of Point Lévis, and from Gros Maule.

7. GRAPTOLITHUS SIMILIS, Hall. (n. s.)

Plate II, figures 1-5.

Description.—Frond consisting of two narrow sublinear elongate stipes, proceeding from a small pointed radicle, from which they diverge almost rectangularly: stipe acquiring its full width near the radicle, having a short space near the base without cellules; extremities somewhat rounded, from the partial development of the cellules. The stipe varies from five to ten hundredths of an inch in width: the cell-partitions, when visible, extend nearly to the back of the stipe, leaving a narrow space occupied by the common body. Surface nearly smooth: cell-partitions seldom seen, and not distinctly visible; the specimens extremely compressed.

Cellules somewhat short and broad, little curved, about twenty-one in the space of an inch, inclined at an angle of 23° to the axis. The cellules are from two to three times longer than wide, this depending on the width of stipe: margin of aperture truncate, making an angle with the axis of from 118° to 130°; the cell-walls show obscure striæ parallel to the aperture. The apex of the denticle is vertically above the posterior basal edge of the second cellule in advance.

The nearest affinities of this with any American species are with those designated by me as *G. sagittarius* and *G. serratulus* from the shales at Norman's Kill, near Albany; but the cellules make a much less angle with the axis of the stipe, and the whole body is less robust than the larger specimens of *G. sagittarius*. It bears a remote resemblance to the figures of *G. nuntius* of Barrande, as given both by Barrande and Geinitz; approaching more nearly to the figures of *G. sagittarius* of Hisinger, as given by Geinitz, than to any of the others; though these figures give a higher angle between the axis and the direction of the cellules. The angle made by the cellules of *G. nuntius* with the axis, as given by Barrande, is 45°, which corresponds with our Norman's Kill specimens; but they differ in other respects. The present species differs from most of the other Canadian species in the straightness of its stipe; and in the low angle made by the cellules, from all others, except *G. indentus*.

The specimens are replaced by pyrites in a dark or nearly black slate, and associated with other forms too imperfect to be identified; one of them resembling *G. quadribrachiatus*, and another *G. bryonoides*.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS SIMILIS, Hall.

PLATE II.

1. A very young individual of this species.
2. An individual somewhat more matured.
3. An enlargement showing the form of the radicle, and the cells near their origin, with a non-celluliferous space between.
4. A fragment of a longer stipe, which is imperfect at both extremities.
5. An enlargement of fig. 4.

Formation and Locality.—Shales of the Quebec group; three miles above the river St. Anne.

8. GRAPTOLITHUS ARCUATUS, Hall. (n. s.)

Plate II, figures 6–10.

Description.—Frond consisting of two simple widely divergent stipes proceeding from a small radicle, and bent backwards or downwards, making on the upper side nearly or more than a right angle with the direction of this radicle, and then curved gently upwards; presenting a broadly arcuate stipe gradually expanding in width from the base to the extremity, and celluliferous throughout its entire length. A single denticle, or similar process, appears above the rootlet. Radicle short, obtusely pointed. The stipe is from four to ten hundredths of an inch in width. The cellules reach nearly to the back of the stipe, leaving a narrow space to be occupied by the common body. Test extremely compressed in the specimens examined, and towards the extremity of the cellules almost transparent. The whole has a white or silvery lustre (probably due to iron pyrites), and no lines or striæ are visible except those marking the separation of the cellules.

Cellules narrow and very little expanded towards the aperture, about twenty in the space of an inch, slightly curving upwards, and inclined to the axis at an angle of about 30°, varying a little with the curvature and development of the stipe; from three and a half to four times as long as broad. Cell-apertures slightly curved, nearly vertical towards the posterior side and arching towards the anterior side. The apex of the denticle, or posterior side of the aperture, is vertically above the base of the third cellule in advance of it.

In some specimens the radicle is broken off, and there is a process on the opposite side, giving the appearance of a radicle on the celluliferous side of the specimen, as if the cellules had been turned downwards; but this appearance is fallacious. In examples where the radicle is broken from the margin of the stipe, the question is suggested whether it may have been a quadribrachiate species; but the pointed radicle in others is opposed to the supposition. In the specimens from which this description is drawn, there are several examples of two individuals lying with the celluliferous margins nearly or quite in juxtaposition; while the stipes crossing each other at a distant point may give an erroneous impression regarding their mode of growth.

On a cursory examination of the specimens before us, this species is readily identified by the peculiar curving of the stipes; differing in this respect from all the bibrachiate forms which have been observed. In the form of the denticles, or free portions of the cellules, this species approaches *G. patulus*; but these parts are less mucronate, and the angle between the axis and the cellules in that species is much greater, and the cellules are narrower. The general form of stipe, except in its peculiar curvature, does not differ essentially from some others previously described; but a comparison of the form of the cellules, their proportionate dimensions, and angle of inclination, will suffice to show its distinctive character.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS ARCUATUS, Hall.

PLATE II.

6. A stipe of a small individual, more than usually curved.
7. A stipe having a process just above and opposite the radicle.
8. A larger stipe, the cellules very clearly preserved.
9. A specimen showing the stipes on both sides of the radicle, and preserving their peculiar curvature very perfectly.
10. An enlargement of a portion of one of the stipes.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

9. GRAPTOLITHUS EXTENSUS, Hall.

Plate II, figures 11–16.

(G. EXTENSUS, Hall: *Geological Survey of Canada*, Report for 1857, *page* 132.)

Description.—Frond consisting of two simple linear very slender stipes, which diverge at right angles to the direction of the minute radicle, and lie in the same plane. Stipe near the radicle one fiftieth of an inch in diameter, and at a distance of four inches from the radicle, one tenth of an inch in diameter. Fragments of single stipes have been observed, having a length of six or seven inches, with a width not exceeding that given above. Surface usually smooth; the striæ formed by the cell-partitions sometimes visible ; the back of the stipe somewhat thickened, and about one fourth of the width occupied by the common body.

Cellules short and comparatively broad, very slightly curved; about twenty-four in the space of an inch, and making with the axis an angle of about 40°. Margins of the aperture truncate, making an angle of 98° with the axis : one third or more of the cellule is free; and near the radicle, one half of the length of the cellule is free. The partitions are distinctly visible in well-preserved specimens; but in most instances they are obscure.

In this collection, the specimens are mostly upon weathered surfaces of the slate ; the substance is often partially removed, and no good impressions are preserved. This species is most nearly allied to *G. similis*, but is always more slender near the base : the serratures are more distinct in smaller stipes, and the angle of the cellules with the axis is much greater ; while the angle formed by the cell-aperture with the axis is much less than in that one. It differs equally from the allied European forms, in some respects approaching the *G. sagittarius* as represented by Geinitz (Graptolithen, etc., pl. ii, fig. 4) ; but it has more the aspect of *G. Nilssoni* (fig. 17 of same plate). It differs essentially however from *G. Nilssoni* as represented by Barrande (Graptolites de Bohême, pl. ii, figs. 16 and 17), and from the figs. 19 and 31 of Geinitz, which our species never approaches in any stage of growth. In our specimens we see the connexion of the stipes with the radicle, and trace them continuously for four or five inches ; and in separated fragments, we have specimens six or seven inches long. None of these offer an approximation in variations of form and proportional distance of cellules, to those represented by Geinitz as different phases of *G. Nilssoni*. We may add, that if such differences exist in the same species, we have then no means of fixing the limits of specific variation, or of determining the species among graptolites of this character, from the separated fragments. The comparatively large number of specimens in the Canadian collection affords good means of specific determination for many of the forms; and unless we could find upon the same stipe, evidences of such variation, we should hesitate to consider the different varieties as one species.

The *G. Nilssoni*, as figured by Harkness (Quart. Jour. Geol. Soc., vol. vii, p. 62, pl. i), differs from our species, and more nearly resembles the figures of Barrande.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS EXTENSUS, Hall.

PLATE II.

11. A single stipe more than four inches long, with the radicle and part of the opposite stipe.
12. A fragment showing a part of the stipe on each side of the radicle, natural size.
13. The radicle and adjacent cellules, enlarged from fig. 12.
14. An enlargement of fig. 12 at a point about two inches from the radicle.
15. A fragment of a stipe where the cellules are distended by iron pyrites. This fragment may belong to a different species.
16. An enlargement from fig. 15.

Formation and Locality.—Shales of the Quebec group ; Point Lévis.

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10. GRAPTOLITHUS PENNATULUS, Hall. (n. s.)

Plate III, figures 1–8 ; and Plate V, figure 9.

Description.—Frond consisting of two stipes, which diverge rectangularly, or are more or less ascending from a small radicle. Stipes narrow at the base, gradually or rapidly increasing in width for about two thirds of their length. At the base they measure not more than three or four hundredths of an inch, and increase to one tenth of an inch in the narrower individuals ; while the widest observed is three tenths of an inch at one third of the length from the base, beyond which point it is somewhat narrower. They are all more or less contracted towards the distal extremity, curved on the celluliferous side, and nearly straight on the back : the terminal cellules are developed in a line nearly parallel with the axis. The proportion of the stipe occupied by the common body is from one seventh to one fourth of the entire width. The test is apparently smooth ; that of the back of the stipe and partitions of the cells seems to be considerably thicker than the outer walls of the cellules.

The cellules, when fully developed, are long, narrow, and curved upwards, making an angle with the axis of from 30° to 45° in different individuals at the base of the cellules, and as high as 70° on the outer part of some of them ; while the average angle, taking a line from the base to the point of the cellule, is from 50° to 57°. The line of the aperture is curved : the pellicle forming the cell-walls extends along the posterior side of the cell-partition next in advance, the line of aperture making an angle with the axis of from 110° to 120° ; while the extremity of the denticle is mucronate. The fully-developed cellules have a length of eight times their width; and in the narrower stipes, the length of the cellule is about five times the width. There are from twenty-four to thirty-two cellules in the space of an inch: (the specimen having thirty-two in an inch is a young individual, in which the cellules are more crowded, and not fully developed.) The apex of the denticle is vertically above the base of the fourth or fifth cellule in advance, varying in the narrower stipes to the third cellule in advance.

This species differs from all the others described, except *G. bifidus;* and this it very much resembles in the young individuals. There is an absence of pustules at the base of the cell-partitions, with a greater thickening of these partitions, and the denticles are usually more mucronate. If uniformity in the divergence of the stipes can be relied upon, this character will aid in distinguishing the species; but this feature may vary from accident, as in one specimen figured, which appears to have been broken in one of the stipes. This species is remarkable for the great development in the width of the stipes, which, in their extremely compressed condition, have the appearance of feathers imbedded in the shale.

The specimens from which these figures have been drawn, present the fossil in a very unsatisfactory condition; and farther collections may show the necessity of separating some of the narrower forms under another specific designation.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS PENNATULUS, Hall.

PLATE III.

1. A young specimen with the minute radicle, the stipes diverging almost horizontally, or rectangularly to the radicle.
2. A young specimen with one stipe entire, and a part of the other, less divergent than fig. 1.
3. A single imperfect stipe of a young or half-grown individual, which is narrower than usual.
4. A larger stipe, which is entire from the base to the apex.
5. A large or full-grown single stipe, which is nearly entire.
6. An enlargement to three diameters from fig. 4, showing the form and proportion of the cellules, and cell-denticles.
7. An enlargement to the same degree as the preceding, from fig. 5.
8. A young specimen where the stipes are twisted near the base, giving an appearance as if the serrations were on the outer or lower side in relation to the direction of the radicle.

PLATE V.

9. A single stipe of this species? The specimen is a large stipe, somewhat obscurely preserved upon the surface of a slab of slate, with *G. extensus*, *G. bryonoides*, and *Phyllograptus ilicifolius*. It is from the same locality with *G. bifidus* at Point Lévis. In the form of the stipe, and its gradual diminution towards the distal extremity, as well as in the absence of visible pustules at the base of the cellules, it has the habit of *G. pennatulus*. Being the only individual observed from this locality, and the resemblance to *G. bifidus* being very close, I have referred it with much hesitation to *G. pennatulus*.

Formation and Localities.—Shales of the Quebec group; three miles above river St. Anne, and at Point Lévis.

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11. GRAPTOLITHUS BRYONOIDES,* Hall.

Plate IV, figures 1-11; Pl. III, figs. 11, 12 (?); Pl. VI, fig. 4 (?).

(G. BRYONOIDES, Hall: *Geological Survey of Canada*, Report for 1857, page 126. *Fucoides serra*, Brongniart, *Végétaux Fossiles*, vol. i, page 71, 1828.)

Description.—Frond consisting of four simple stipes, united in pairs at their bases, and connected by a short funicle of variable length, from the centre of which proceeds a minute pointed radicle. The stipes diverge at various angles (dependent probably on distortion from pressure); narrow at their origin, and abruptly expanding above, they acquire their full width within the distance of three or four cellules, and maintain the same throughout their length to near the distal extremity, which is somewhat abruptly rounded and occupied by the partially-developed cellules. The full width of the stipes in young individuals is often not more than one twelfth of an inch, and in mature specimens about one seventh of an inch; the base having a diameter of not more than two or three hundredths of an inch. The common body occupies a very narrow space, and the solid axis is strongly defined in the flattened specimens. The substance of the stipe or pellicle is quite thin and apparently smooth, the only markings visible being the oblique striæ made by the cell-partitions.

Cellules elongate, of medium width, somewhat curved, and in the fully-developed condition about four times as long as wide, making an angle of from 40° to 50° with the axis; free for about one fourth of their length; about from twenty to twenty-four in the space of an inch, varying in different individuals and in different stages of growth. Aperture curved, making an angle of about 110° with the axis; the cell-denticles pointed, and slightly curved forward: cell-partitions usually well marked, and near the base, making a much less angle with the axis than towards the aperture.

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* I have little doubt that this species is identical with *Fucoides serra* of Brongniart (Vég. Fossiles, p. 70, 1828). The locality of that species is "*Pointe Levi près Quebec*," which is the same with that of *G. bryonoides*: and the figures of Brongniart correspond with figs. 9 and 10 of plate 4 of this memoir. The *Fucoides dentatus* of the same author is also probably identical with *G. pristiniformis* of this memoir, being from the same locality. It is only since these descriptions have been in print, and published references made to them, that I have discovered this identity, or I would have proposed to substitute the specific names of Brongniart for those given by me in 1857. I take the first opportunity of making the correction.

When the funicle is broken, this species sometimes occurs like the bibrachiate forms, as in fig. 5 of plate iv, and in that condition bears some resemblance to *G. nitidus*; but its stipes are wider, its habit more robust, the cellules more curved, making a greater angle with the axis; the denticles coarser and more equilateral, and usually mucronate or sub-mucronate. No pustules at the base of the cell-partitions, as in *G. nitidus*, have been observed in this species. There is also a resemblance between *G. patulus* and this species; but in that one the stipes are usually more slender, the denticles more mucronate, the curve of the aperture much greater, and the cells make a much greater angle with the axis.

This species is associated in the same shales with *G. nitidus*, *G. extensus*, *G. constrictus*, and *Phyllograptus ilicifolius*. I have united with this species the specimen represented in figs. 9 and 10, of plate iv, though it presents variations in some of its characters. A small portion of one of the stipes near the base of this shows a number of cellules or serratures equal to twenty-six in the space of an inch. Its affinities are more nearly with *G. bryonoides* than with any other; and having but this individual, I refer it for the present to that species.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS BRYONOIDES, Hall.

PLATE IV.

1, 2, 3. Young individuals of this species.
4. An older individual.
5. A young specimen preserving two of the stipes, the funicle having been broken.
6. An enlargement from fig. 1, showing the radicle, funicle, and origin of the four stipes, with a few of the earlier cellules.
7. An older and larger specimen.
8 An enlargement showing the character and proportions of the cellules.
9. A small individual, preserving the four stipes in part, which are somewhat more slender than the usual forms of this species.
10. An enlargement of the base of the specimen, showing the cell-denticles on one of the stipes, and a proportionally longer funicle than in fig. 8.
11. An extremely elongated stipe, the lower end showing the commencement of growth; the distal extremity is broken.

PLATE III.

11. A fragment of a stipe from the rough shales, with *Phyllograptus ilicifolius*. In the character of the cell-denticles it resembles the specimen pl. iv, fig. 9, and with that one may constitute a distinct species.
12. An enlargement of a part of the specimen fig. 11.

Plate VI.

4. A frond in which three of the stipes, and the base of the fourth, are preserved. The specimen shows some peculiarity in the union of the parts by the slender funicle.

Formation and Localities.—Shales of the Quebec group; Point Lévis, Grôs Maule, and river St. Anne.

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12. Graptolithus Bigsbyi, Hall.

Plate XVI, figures 22–30.

(Phyllograptus similis, Hall: *Geological Survey of Canada*, Report for 1857, page 140. Compare *Didymograptus caduceus*, Salter: *Quarterly Journal of the Geol. Society*, vol. ix, p. 87.)

Description.—Frond broadly oval or sub-oval, consisting of four somewhat semi-elliptical stipes, which are nearly straight or slightly curved on the non-celluliferous margin, and broadly curved on the celluliferous side; all closely united at the base in a radicle (?), and from which they are abruptly recurved. These stipes are more frequently distinct at the apex, while in some individuals they are in contact or apparently united at that point, but always separated in the centre for a distance of three fourths their length. Entire length of specimens from four to six tenths of an inch, and width three tenths of an inch, exclusive of the denticles. The individual stipes, in the centre of their length, are twelve hundredths of an inch wide. Radicle undetermined. Cellules from thirty-two to thirty-six in the space of an inch, narrow at the base, gradually ascending and curving outwards, except those near the base, which are recurved: cell-margins curved, and extended in mucronate points, which are the continuation of the cell-partitions. Test thin and smooth, with the exception of the cell-partitions.

This species presents a great variety of aspects, and the most critical examination has left some doubt as to its original mode of growth. The more perfect specimens are broadly oval, the diameters about as three to four; and where the stipes are apparently conjoined, at the two extremities, there is a vacant space in the centre (extending about three fourths of the length, and from six to eight hundredths of an inch in width), except that some portions of one or both the other stipes are visible. In one or two individuals, there is a linear body extending longitudinally through this space, which may have been originally the axis; but its relations cannot be determined. Examinations have failed to exhibit any satisfactory evidences of the existence of a radicle. In most of the specimens the stipes are united at one extremity and free at the other; while their curvature is such, that if continued, they would meet. In these specimens the four stipes are often distinctly seen, two usually showing the non-celluliferous margins; while sometimes three, and rarely the four stipes show the celluliferous margins.

The individuals are extremely numerous, but in almost all instances the characters are more or less obscured by the stipes being slightly separated by intervening laminæ of slate, or by the weathering of the surface. On a single piece of slate of about a foot long by six inches wide, there are more than one hundred individuals; but nearly all of these are so obscured by weathering, that they afford little means of determining the characters or mode of growth. In the whole collection, there are not more than one or two species of which the individuals are more numerous than of this, and in no other are the characters so indistinct.

From the deep curving cellules and broad stipes, which are often apparently conjoined at the apex, I have supposed that they may, at some period of growth, have been joined along the non-celluliferous side for the entire length. On this account, I had originally referred the species to the genus *Phyllograptus.*

In some of the specimens, where two of the stipes are spreading, and show the celluliferous margins, the non-celluliferous face of a third stipe often stands vertically between them, like a stem. These forms resemble the *Graptolithus caduceus* of Salter, which was obtained by Dr. Bigsby from "the Lauzon Precipice,"* and I have hesitated in regard to making of these a new species. The name of *Phyllograptus similis* was applied to such forms as figs. 26, 29, and 30; but when it became apparent that all the other varieties of form must be referred to the same, it was necessary to remove it from that genus; and since I had already named another species *Graptolithus similis*, I take great pleasure in dedicating this to Dr. J. J. Bigsby, who early explored the geology of the northern portion of our continent, and who, in later years, has never ceased to interest himself in American geology, and to aid in its progress.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS BIGSBYI, Hall.

PLATE XVI.

22, 23, and 24 illustrate a common condition of this species, where two of the divisions show the lateral faces, while the non-celluliferous edge of a third division is seen lying nearly vertically in relation to these. The fourth division has been broken off in the separated film of slate.

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* This locality is probably the same with that which has furnished the greater part of the graptolites here described; the precipitous heights of Point Lévis being in the seigniory of Lauzon.

25. A specimen showing the lateral faces of two divisions. Below these, in the shale, are seen the non-celluliferous edges of the two other divisions.

29 and 30 show a still closer arrangement of the parts, and the contiguity of the non-celluliferous edges at the apices, which are scarcely perceptibly separated in the shale.

26. An individual where the apices of the divisions are in contact, either conjoined, or accidentally so placed, with a narrow space in the centre. In obscure specimens it is difficult to separate such forms from *Phyllograptus*.

27. An individual where the divisions are equally spreading: one of them preserving only the base of the stipe.

28. The same enlarged.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

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13. GRAPTOLITHUS DENTICULATUS, Hall.

Plate IV, figures 12–16.

(G. DENTICULATUS: *Geological Survey of Canada*, Report for 1857, page 132.)

Description.—Frond consisting of four simple stipes proceeding from a simple radicle. Stipes slightly ascending at their origin, but immediately and strongly recurved, again bending gently upwards from the middle towards the extremities; slender at the origin, and gradually expanding to a width of from nine to twelve hundredths of an inch (exclusive of the denticles), which it almost uniformly maintains. Substance of the stipe extremely thin, and marked on each margin by a linear filiform ridge, like the ordinary solid axes of these bodies. In the impressions left on the removal of the substance, each margin shows a continuous filiform groove in the place of the thickened or solid margin of the stipe; the groove on the celluliferous or denticulate side being much stronger than that on the back of the stipe. Surface apparently smooth throughout. Cellules consisting of small mucronate equilateral denticles, placed vertically on the margin of the stipe, and rising immediately from the thickened solid edge: denticles spreading below, slightly curving, and united at their bases by a thin pellicle; varying in their distance on different parts of the stipe, and apparently in different stages of growth; sometimes twenty-four in the space of an inch, near their origin, while elsewhere the average number is from eighteen to twenty; the lower number marking the strongest stipes measured.

This species is very peculiar, differing not only from the associated species, but from all others in the arrangement of its denticles.

The specimen originally described under this name is a fragment (pl. iv, fig. 14), consisting mainly of an imprint in the shale, the substance of the fossil being preserved in some parts. The solid axis on the denticulate margin is clearly defined in the impression, and in some places the substance remains, and is expanded at each denticle on the upper side so as to occupy the base of each depression. The cellules terminate in so minute a point that no aperture is visible; but in a longitudinal division of some of them, they appear to have been hollow tubes. The back of the stipe is clearly marked (as is usual in the graptolites) by the presence of a distinct solid axis, which in no respect differs from the ridge on the opposite margin, except that the latter extends into the base of the cellules.

A further study of the collection has shown that some obscure imprints in weathered shale are of the same species. These imprints, at a few points, retain portions of the pellicle, and the form of the cellules is well preserved; they reveal moreover the mode of growth, as shown in figs. 12 and 13 of pl. iv; thus indicating their relation in this respect to *G. bryonoides* and *G. quadribrachiatus.* The recurved position of the stipes is a feature of *G. bryonoides*, but less extreme than in this one. This species may be readily identified by the pointed cellules, vertical to the axis, which *appear* to be entirely separated from the common body, except in well-preserved portions, where in a few examples they are shown to be connected at the base by a continuation of the cell-wall above the solid axis.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS DENTICULATUS, Hall.

PLATE IV.

12. A small imperfect specimen, preserving three of the stipes.
13. A larger and more nearly entire specimen, showing the four stipes. Their junction at the base is not quite satisfactorily shown.
14. A part of a single stipe, in which the cellules are well shown on one part; while they are compressed and nearly obliterated on the left of the curve.
15. An impression of a part of a stipe which is nearly straight; the imprint of the axes or thickened margins is not defined.
16. An enlargement from figure 14, showing the form of the cell-denticles, and the strong marginal axes; one portion represented with the substance remaining, and the other as an imprint.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

14. GRAPTOLITHUS FRUTICOSUS, Hall.

Plate V, figures 6–8; and Plate VI, figures 1–3.

(G. FRUTICOSUS : *Geological Survey of Canada*, Report for 1857, page 128.)

Description.—Frond consisting of two pairs of ascending and slightly curved stipes arising from the two sides of a long slender radicle, which is divided above: the stipes are celluliferous on the inner or adjacent margins, little divergent at the bifurcation, and continuing for a half or two thirds of their length nearly straight; above this they curve gently outwards, presenting, when not distorted, a very beautiful and symmetrical form. The stipes gradually increase in width from their origin, being at the base one fiftieth of an inch, and in the widest part one twelfth of an inch, exclusive of the denticle. The proportion of the stipe occupied by the common body is extremely narrow.

Surface smooth, or with scarcely visible striæ at the lines of the cell-partitions: axis very slender; test thin and fragile. Radicle half an inch in length. Cellules short and broad, making an angle with the axis of about 38°; the length from two to three times the diameter, and free from a third to a half of the entire length, according to their development; variably curving in different parts of the stipe. Aperture wide, apex pointed, scarcely mucronate, and sometimes acutely rounded. About fifteen cellules in the space of an inch, varying slightly in different parts of the stipe: near the base the serrature or length of the denticle is equal to the width of the stipe, while in the wider portions it is less than half the width of the stipe.

This species, in all the examples that have been observed, is a very distinct and easily recognized form. Wherever the radicle is preserved, it is longer than in any of the other species: this part bifurcates above, and the divisions, moderately diverging, represent what I have termed the funicle in the quadribrachiate forms; from each extremity of this, the stipes originate. All the divisions are little divergent, and the frond grows upwards like a small shrub. The form of the cellules differs from other species here described, except perhaps *G. indentus*, which is readily distinguished in its mode of growth, as well as by other characteristics.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS FRUTICOSUS, Hall.

PLATE V.

6. A small individual with the radicle and extremities of the stipes broken off.
7. An enlargement from fig. 6. The serratures are either imperfect or shrunken, and do not present the characters seen in better-preserved specimens.
8. An individual nearly entire, but badly preserved in the outline of its parts.

PLATE VI.

1. A fragment showing two of the stipes entire, and the bases of two others; the radicle extending to the margin of the specimen.
2. A specimen preserving three of the stipes, one of them entire, and showing some irregularities in the bifurcation where the one is broken off.
3. An enlargement of the right-hand stipe of the specimen fig. 1.

Formation and Localities.—Shales of the Quebec group; at the upper end of Orleans Island, and three miles above river St. Anne.

15. GRAPTOLITHUS QUADRIBRACHIATUS, Hall.

Plate V, figures 1–5; and Plate VI, figures 5, 6.

(G. QUADRIBRACHIATUS, Hall: *Geological Survey of Canada*, Report for 1857, page 125.)

Description.—Frond composed of four simple undivided stipes arranged bilaterally, or two proceeding from each extremity of the funicle. Stipes slender, very gradually increasing in width from their origin, as far as traced; usually straight, sometimes slightly curved; width from two to four hundredths of an inch at the base, and in the most perfect examples, nine hundredths of an inch at the widest part. The back of the stipe is marked by a filiform axis, and there is scarcely more space occupied by the common body. Test thin, though well preserved in the finer shales. Surface of cell-walls distinctly striated parallel to the apertures, and the cell-partitions visible nearly to the back of the stipe.

Cellules narrow, scarcely curving, and slightly expanding towards the aperture, making an angle with the axis of about 38°; the length equal to about four diameters, the free portion being from one third to two fifths their entire length. The margin of the aperture is nearly straight, or very slightly curved, making an angle of from 95° to 100° with the axis. The number of cellules in the space of an inch is from twenty-two to twenty-four, dependent on the distance from the origin of the stipe, and on the degree of development. The apex of the denticle, or posterior point of the aperture, is a little below the base of the second cellule in advance. Cell-partitions thin, and usually not well preserved.

This species, when entire, is readily distinguished from *G. bryonoides* by its straight and more slender branches, and by the general aspect and expression of the fossil; it has only a remote similarity with the other quadribrachiate forms. In separated or double stipes it bears some resemblance to *G. arcuatus*, except that it is less curved, and the form of the cellules is distinctive. From the other bibrachiate forms, it is very readily distinguished on comparing the form of the cellules.

I had heretofore regarded this species as possessing a disc, like *G. crucifer* and others ; but on examination of all the specimens which can be satisfactorily identified with it, not one has shown a disc. The discs with four stipes, which are broken off so close that no serratures are visible, cannot be satisfactorily identified with this or any other species, and are therefore left in doubt at this time. They may be regarded as belonging to *G. crucifer*, or to the young of *G. Headi*.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS QUADRIBRACHIATUS, Hall.

PLATE V.

1. A large specimen with stipes vertically compressed.
2. A young specimen in which one of the stipes appears to be subdivided.
3. An individual with stipes a little curved, the back of the stipe visible, and showing no serratures.
4. A frond with one of the stipes broken off; one showing the cellules and distinct striæ parallel to the cell-partitions, while the other two are turned so as to obscure the cellules.
5. An enlargement from fig. 1 : the stipe has been vertically compressed, causing the cellules to show a less angle with the stipe than in the normal condition.

PLATE VI.

5. A frond preserving one stipe partially entire, and others broken off: the funicle and radicle-point are well preserved.
6. An enlargement from the specimen fig. 5, showing the form and proportion of cellules in their more perfect preservation, with the striæ parallel to the cell-margins well preserved.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

16. GRAPTOLITHUS CRUCIFER, Hall.

Plate V, figure 10.

(G. CRUCIFER : *Geological Survey of Canada*, Report for 1857, page 125.)

Description.—Frond composed of four simple, strong stipes, united at their base by a small thickened disc. Stipes strong at the base ; the two pairs connected by a short funicle, which is without a visible radicle, The specimen lies with the celluliferous face downwards, and the stipes near their origin present only the back, which shows them to be strong, and of considerable substance, and measuring at that point five hundredths of an inch in width. Extending from the disc, the stipes are gradually turned on one side, and in their greatest width measure seventeen hundredths of an inch in diameter, including the denticles. Cell-denticles sub-mucronate, rising above the margin almost vertically; about twenty-two in the space of an inch.

This species preserves the general form of *G. quadribrachiatus*; but is more robust, and the stipes are united in a central disc. The specimen is upon a weathered surface, and very obscure; the characters being drawn from the general form and proportions. The cell-denticles are visible on a part of three of the stipes, but we are unable to trace the direction or existence of any cell-partitions. The denticles in their prominence resemble those of *G. denticulatus*; and broad stipes of *G. bifidus* have likewise some analogy with this species; but as our only specimen is imperfect, no minute comparisons can be made. It is a smaller species than *G. Headi*, but with a comparatively broader stipe, and more erect cell-denticles. In *G. crucifer* the disc is quadrilateral, with concave sides, and is somewhat oblong; while in *G. Headi* the disc is larger and essentially square, the margins being very nearly straight.

In the specimen described, the disc is without markings, as are also some other discs which may belong to this species; while a single specimen shows concentric striæ parallel to the margins.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS CRUCIFER, Hall.

PLATE V.

10. View of the specimen from which the description is drawn.
13. The disc of a young individual probably of this species.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

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17. GRAPTOLITHUS ALATUS, Hall.

Plate VI, figure 9.

(G. ALATUS: *Geological Survey of Canada*, Report for 1857, page 127.)

Description.—Frond consisting of four stipes (probably simple); their bases united in a thickened disc, the central portion of which is about seven tenths of an inch in extent, and uniting to the stipes continues along their margins for an inch and a quarter, giving an extremely alate appearance. Stipes strong, angular on the back or non-celluliferous margin: test thick: cellules unknown.

The only specimen known consists of the disc and parts of three of the stipes; the longest one extending a little beyond the limits of the disc, or so far that the alation produced by the disc is not distinguishable. The lower or non-celluliferous side is presented to view, and we know nothing of the extension of the stipes, nor of the cellules. It is probably one of the simple-stiped species, and of rare occurrence, since no other specimens are known which can be identified with it.

EXPLANATION OF FIGURE OF GRAPTOLITHUS ALATUS, Hall.

PLATE VI.

9. The specimen represented as it occurs on a fragment of slate. The back of the stipes shows faint indentations, but they are made too strong in the engraving.

Formation and Locality.—Limestone of the Quebec group; Point Lévis.

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18. GRAPTOLITHUS HEADI, Hall.

Plate VI, figure 8.

(G. HEADI, Hall: *Geological Survey of Canada*, Report for 1857, page 127.)

Description.—Frond robust, four-stiped; the stipes in pairs, joined by a short funicle at the base, and united in a broad thickened quadrangular disc. Stipes strong, somewhat alate near the base from the extension of the substance of the disc for a short distance along their margins, extremely elongate, and extending in a nearly direct line towards their extremities; celluliferous on one side. The width in a transverse direction, at the junction with the disc, is six hundredths of an inch; and in the widest portion, fourteen hundredths of an inch. Disc quadrangular, nearly square, slightly extended along the stipes, with straight margins in the spaces between; measuring in the specimen examined, one inch and one eighth in each diameter across the centre.

Cellules elongate, distinctly curved, making with the axis an angle of about 50°; length four or from four to five times the diameter at the aperture: denticles sub-mucronate, sub-erect, about twenty-four in the space of an inch. The margin of the aperture is apparently curved; its angle with the axis cannot be satisfactorily determined from the specimen. Cell-partitions strong.

The specimen from which this description is drawn, consists of the disc and a part of two stipes, the other two being broken off just beyond the disc; one of the stipes measures nearly seven inches from the centre. When the disc is preserved, this species can be readily distinguished. Separated stipes bear a near resemblance to *G. bryonoides*; but the abrupt, narrowing at the base of the stipes, and the shorter denticles, characterize *G. bryonoides*. In the specimen described, we have little more than an impression of the stipe, and this is in a coarse material; so that there still remains some obscurity regarding the surface of the test, and the exact form of the cellules and their apertures.

EXPLANATION OF FIGURE OF GRAPTOLITHUS HEADI, Hall.

PLATE VI.

8. A representation of the specimen of the natural size, and as it occurs on the surface of the stone. (The upper separated portion of the stipe is placed a little lower in the figure than it is on the stone, in order to bring it within the dimensions of the plate.)

Formation and Locality.—Shales of the Quebec group; Point Lévis.

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19. GRAPTOLITHUS OCTONARIUS, Hall.

Plate X, figures 1, 2.

(G. OCTONARIUS, Hall: *Geological Survey of Canada*, Report for 1857, page 124.)

Description.—Frond consisting of eight stipes uniting in pairs at the base, and each pair again united in a similar manner, making one half the frond; the two parts are joined by a funicle, in the centre of which is a small rootlet. The two sides are equal and symmetrical, giving a bilateral arrangment to the whole. Stipes narrow and rounded at the base, having a diameter of from two to four hundredths of an inch below the bifurcations; in the figured specimen, at a distance of from one half to three fourths of an inch from the base, they are eleven hundredths of an inch wide.

Solid axis distinct, the common body occupying a very small proportion of the whole width. Cellules elongate, distinctly curved, expanding; making an angle of from 30° to 35° with the axis; the aperture is twice as wide as the base; the free portion is a little more than one third of the entire length. Margin of aperture slightly curved in the mature cell, and more distinctly in the young, making in the former an angle of 120° with the axis. The denticles are pointed, scarcely sub-mucronate, twenty-four in the space of an inch. Cell-partitions strongly marked, the line of separation extending nearly to the back of the stipe.

In this species the stipes resemble those of *G. bryonoides* in their width, form, and proportion of cellules and cell-denticles; but the number of stipes in entire specimens is a characteristic feature. In single stipes or in pairs of *G. octonarius*, there is, as shown in the figures, a longer space at the base without cellules, and in the double or quadruple stipes the difference of character is obvious. In the union of the two stipes in *G. bryonoides*, the funicle proceeds from the back of the stipes, or the non-celluliferous side; while in the union of two stipes in *G. octonarius*, the continuation below, uniting with the adjacent pair, is not from the back of the stipes alone, but the two appear to be united laterally and diverge at a different angle; as will be seen on comparing the figures of the two species. Fragments of *G. patulus* bear some resemblance to this species, but a comparison shows important differences.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS OCTONARIUS, Hall.

PLATE X.

1. A specimen of natural size, much broken and distorted from pressure.
2. An enlargement from the preceding figure.

Formation and Locality.—Shales of the Quebec group; Grôs Maule.

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20. GRAPTOLITHUS OCTOBRACHIATUS, Hall.

Plate VII, figures 1–7; and Plate VIII, figures 1–4.

(G. OCTOBRACHIATUS, Hall: *Geological Survey of Canada*, Report for 1857, page 122.)

Description.—Frond consisting of eight simple stipes, which are united in pairs at their bases: these have their origin from a short funicle, which proceeds from a radicle in the centre. Each extremity of the funicle is divided, and these divisions are again bifurcated, giving origin to the four stipes on each side, which are thus bilaterally arranged. The funicle and bases of the stipes are united in a broad thickened disc, composed of the same substance as the other parts of the fossil: disc octagonal, the sides concave between the stipes, and the angles extended upon the margin of the stipes. Stipes robust, equal, linear, elongate, proceeding in right lines from the centre.

Within the disc or near it the stipes measure five hundredths of an inch in width; and beyond this the width, including the serrature, is thirteen hundredths of an inch. Test thick: the common body occupies sometimes about one third of the entire width. Cellules long, strongly curved, the breadth at the aperture three or four times as great as at the base; length a little more than three times the width at the aperture; making an angle with the axis of 20° near the base of the cell, and from 52° to 55° near the aperture. Margin of the aperture nearly straight, making an angle with the axis of 105°; and sometimes, when compressed, still greater. Denticles obtuse, about nineteen or twenty in the space of an inch.

This species is remarkable for its extremely elongate stipes and strong central disc. Some of the largest individuals, with the stipes expanded, have extended over an area of at least sixteen inches in diameter. The stipes are extremely robust, and in their original state appear to have been quadrangular; the measurement across the back of the stipe, when flattened, being seven ninths as great as the lateral measurement of the flattened stipe below the cell-denticles. The size of the stipes is not greater than in *G. Headi;* but these have a more rigid aspect, and are readily distinguishable when the cellules or cell-denticles can be seen.

All the specimens, with one exception, present the exterior or non-celluliferous side at the base; the disc and stipes adhering to the stone on the celluliferous face; so that it is only towards the extremities of the branches, where they are turned on one side, that the full width or form of the cellules can be seen. An impression of a short fragment of the celluliferous surface of one of the stipes shows strong deep indentations. The cellules vary but little in their distance or approximation, from seventeen to twenty in the space of an inch being the extremes of variation observed. The disc is not uniform in its proportions, nor regular in form, nor does it always appear to bear the same proportion to the strength of the stipes; it has sometimes a very symmetrical octagonal form: its substance is often considerably thickened and striated parallel to the margins, which are thinner, attenuating from the centre. The cellules are subject to variation from the direction in which the stipes have been compressed, and in this respect show a greater variety of appearances than any other species in the collection.

This species exhibits some differences in its mode of growth, and the number of stipes is not invariable. One specimen presents but seven stipes; the centre, funicle, and divisions on one side being of the normal character, while on the other, one division of the funicle does not bifurcate, but continues as a single stipe, giving seven as the entire number of stipes, with a small seven-sided disc. In another individual we have five stipes only; the funicle and disc exist as in the others, but the subdivisions have taken place only on one side, while on the opposite the stipe continues simple. The presence or absence of the central disc, however, cannot be relied upon for specific or other distinction, since both in this species and *G. Logani* we have specimens of the same species, preserving their characters in all respects, except the disc. In the specimen fig. 2, plate viii, we have the central portion of an individual in which there is no evidence of the disc having existed. In its form and mode of division it corresponds in all respects with those specimens possessing the discs; and as it occurs in the same association, we cannot suppose it otherwise different.

In its long linear stipes, this species resembles *G. sagittarius* (Hall, Pal. New York, vol. i, plate 74, fig. 1; perhaps not the European species of that name); but the branches are stronger and the serrations coarser; it is moreover associated with a group of species, all of which are quite distinct from the New-York species with which *G. sagittarius* occurs.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS OCTOBRACHIATUS, Hall.

PLATE VII.

1. A large individual preserving two of the stipes to the length of eight inches, and another to nearly the same extent, while the rest are broken off at less distances from the disc. The flexibility of their substance is well shown in the recurved stipe at the left-hand side of the figures. Although this specimen preserves the most extended stipes of any in the collection, the disc is smaller than in several of the other specimens.
2. The exterior of a large disc of this species, with the stipes broken off a little beyond its margin. The two longer portions are so turned as to show the cellules.
3. A portion of a large disc, showing the exterior or non-celluliferous face of the frond, and preserving portions of four of the stipes.
4. A frond with the stipes broken off at different distances from the centre. The substance of the disc or cup is imperfect,—a condition which apparently existed while the body was in a living state.
5. An enlargement from one of the stipes at *c*, looking upon the apertures of the cellules, which are somewhat compressed.
6. An enlargement from the same at *b*, where the substance is laterally compressed.
7. An enlargement from the same, where the substance is obliquely compressed at *a*.

Figs. 5 & 7 are taken from casts made in the impressions left by removal of the substance of the graptolite.

PLATE VIII.

1. A symmetrical frond preserving parts of all the stipes, two of them apparently almost entire; several of them had been abruptly bent before being imbedded in the stone.
2. A frond preserving eight stipes, but without a disc. The specimen does not afford any evidence that a disc has ever existed.

3. A frond with small disc and somewhat slender stipes. One side preserves the usual character of four stipes, while the other has but three.

4. A frond which is abnormally developed; one side preserving the four stipes with the disc, while on the other side the funicle is apparently extended in a single stipe only.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

The *G. Logani* is the only species with numerous unbranched stipes which we know of at this time in the Quebec group. All the other species with more than eight stipes, have them branched beyond the commencement of the cellules. In the Hudson River formation, however, we have a single analogous species, the *G. multifasciatus.* In that one the stipes are forty or more in number, and are apparently simpler after they become celluliferous.

In the progress of development of the graptolites of this type, we have traced them through the two, four, and eight-stiped forms. Those with two stipes have never shown the cup or disc; while some of the latter two forms have discs, and others apparently never possessed this appendage. The subdivision into stipes appears to go on by a regular duplication of the parts; and the stipes in perfect forms are bilaterally arranged, beginning with those having two; which proceed, one on each side, from a rootlet. With the exception of *G. fruticosus*, the four-stiped forms originate from a minute radicle; while on each side of this centre, the body extends a short distance in the funicle, which is not celluliferous; and then subdivides equally, no cellules occurring below the division. In the next form, the funicle is divided at each extremity as before, and again divided or bifurcated below the origin of any cellules. Were this mode of subdivision to continue, the next step in the development would give us sixteen stipes; but we have no form of this kind in the collections.

In the next form, with simple stipes, we find the *G. Logani*, which presents a wide variation in the number of stipes; so varied indeed that the two extremes might, if examined separately and without the intermediate forms, be regarded as two distinct species. The variation in the number of stipes in this species extends from eighteen to twenty-five: some divisions of the funicle are equally, and others unequally developed in the number of stipes which proceed therefrom.

21. GRAPTOLITHUS LOGANI, Hall.

Plate IX, figures 1–9; and Plate XI, figure 7.

(G. LOGANI: *Geological Survey of Canada*, Report for 1857, page 115.)

Description.—Frond composed of numerous slender simple stipes, subequally disposed on the two sides of their origin, or of the minute point indicating the radicle. All these, in their perfect condition, have their bases embraced within a broad disc. Radicle sometimes well marked: funicle short, simple for about three sixteenths of an inch, when it is divided at each extremity, the divisions diverging at an angle of 150° or more. Each division is again subdivided with more or less regularity, and always near the base, until there are from eighteen to twenty-five simple stipes radiating from the central disc. There are rarely more than three bifurcations after the first division of the funicle, and these all take place within the limits of the disc. No cellules are visible on the stipes below the last bifurcation, though they do occur within the limits of the disc. On the inner or celluliferous side of the disc, the divisions of the funicle, and the bases of the stipes beyond, are grooved along the centre. The disc is from one to nearly two inches in diameter in different individuals, and with sides corresponding to the number of stipes, between which the margin is concave. The substance of the disc is corneous like that of the stipes, extremely thin, though composed of double walls; somewhat thickened near the centre, and forming only a thin translucent pellicle towards the margin. The surface is usually and perhaps always smooth in the centre; while towards the margin, and parallel with it, are fine striæ of growth.

The transverse diameter of the stipes, within the limits of the disc, is from two hundredths of an inch at the base to four hundredths of an inch at its outer margin. The vertical diameter, including the cell-denticles, is six hundredths of an inch. The stipe is thickened on the back, and about one fifth the width is occupied by the common body. The full width of the stipe is attained at about two inches from its origin. Some of the stipes have been traced for seven and a half inches from the centre of the disc, and their extremities are still imperfect. The cellules are short narrow and straight, making an angle with the axis of about 35°, and free for about two fifths of their length, which is less than three times the diameter of the aperture. The margin of the aperture makes an angle of from 90° to 95° with the axis: denticles acute, from twenty-two to twenty-six in the space of an inch; the prevailing number being twenty-four. Partition-walls thin, and obscurely marked on the surface of the stipe.

This species, when the form is entire, is readily recognized by its numerous simple elongated stipes. The separated central portions, whether with or without the disc, may be known by the short funicle, and the numerous subdivisions near the centre. The stipes differ from those of any other species in their proportions, and the form of the cellules and denticles. In these separated parts there is some resemblance to *G. arcuatus;* but that species has the stipes more curved, with a different form of cell-denticle, and is moreover marked by the frequent occurrence of the minute radicle attached to the separated stipes, as well as by the presence of cellules nearer to the origin of the latter.

The great variation in the number of stipes shown to occur in *G. Logani*, as well as what occurs in a lesser degree in *G. octobrachiatus*, is sufficient evidence that strict specific characters cannot be founded on this feature alone, in species where the stipes are numerous. From what we are able to observe, it would appear that the disc of *G. octobrachiatus* extends itself with the age of the individual; though in *G. Logani* there is no perceptible difference in the width of the stipes near the base, whether the discs are larger or smaller. In those specimens of this species which are without the central disc, or where this part may have been removed, the stipes are always more slender towards the base than when they are embraced within the central disc.

The margins of the disc are slender, and sometimes found broken between some of the stipes, without injury to the rest of the body. The parts so broken assume the same outline as if entire, and may probably have been afterwards extended to correspond with the other portions. This feature is seen in plate IX, fig. 4, where a specimen preserving half of the disc shows that in three spaces between the stipes the disc had been partially broken away, and appears to have been in process of reproduction.

In specimens showing the inner side of the frond, we find a distinct groove marking the centre, the funicle, and the bases of the stipes: this is seen whether the disc is preserved or not, and appears to be an organic feature. This groove, corresponding to the central axis, likewise extends for some distance along the celluliferous portion of the stipe; and the indentation, being thus interrupted along the centre, is shown more strongly on each margin, appearing like a double indentation or serrature.

On the opposite side of the frond, when well preserved, the stipes near their bases, often appear to have a double axis, or an elevation on each side. This feature seems to be due to pressure, or to the filling of the tube on the two sides, while the centre has been contracted. It is clearly an accidental feature, probably dependent on the nature of the surrounding material, at least in part, since some specimens from their origin are full and round on the back of the stipes.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS LOGANI, Hall.

PLATE IX.

1. A specimen of slate, preserving portions of three individuals, (two only given in the illustration.) The disc had probably been removed by maceration before they were imbedded, but the stipes are preserved to a length of more than seven inches. It does not appear that this exhibits the entire skeleton : the stipes were originally longer. The serrated margins are not always shown at equal distances from the centre; but this is due to accidental position, some stipes showing the exterior surface for some distance, and then gradually turning and becoming flattened laterally.
2. A specimen showing the disc almost entire.
3. An individual showing the exterior surface; the central portions entire, with the impression of the connecting disc, some portions of which remain attached to the stipes. The extent and outline of the disc are distinctly seen. The appearance of serratures is due to exfoliation, which shows the impression of the celluliferous side of the stipe upon the stone.
4. A specimen exhibiting the half of an individual, with the disc unequally extended between the rays. The margins are all apparently entire, and this inequality, to whatever accident due, existed in the living animal.
5. Exterior view of an individual showing some remaining portions of the disc; the stipes are all broken off beyond the bifurcations.
6. Another individual showing the inner side, with the commencement of the cells, which appear in some places as if in double series; the substance of the disc is removed.
7. Enlargement of the exterior surface of the central portion of the specimen fig. 5.
8. Enlargement of the inner surface of the specimen fig. 6, giving the appearance of a double series of cells separated by a depressed line in the substance of the stipe. Sometimes this separation appears to be actual, while elsewhere the apparent division is due to the depression along the centre.
9. Enlargement of a fragment of a stipe, showing the form and proportions of the cellules.

PLATE XI.

7. The central part of an individual without disc, showing five stipes on one side and four on the other. This is supposed to be an abnormal form of G. *Logani.*

Formation and Locality.—Quebec group; Point Lévis.

GRAPTOLITHUS FLEXILIS, Hall.

Plate X, figures 3–9.

(G. FLEXILIS, Hall: *Geological Survey of Canada*, Report for 1857, page 119.)

Description.—Frond multibrachiate, composed of numerous slender branching stipes, which are bilaterally disposed on the two sides of their origin. Radicle minute: funicle short, being little more than one tenth of an inch in length, dividing at the two extremities, the parts diverging at an angle of about 105°; each one of these again divides within the space of a tenth of an inch, making eight principal stipes, which are again several times bifurcated. Cellules commencing above the third bifurcation, perhaps above the second. Stipes slender flexuous, the branches diverging at a lesser angle at each successive bifurcation: stipes and branches filiform at base, and measuring in their full width, where the cellules are distinct, from four to seven hundredths of an inch, (a very small proportion of the width being occupied by the common body); curving from the base, and slightly arcuate in their entire length. The cellules are usually on the inner side of the curve. In the entire length from the first division of the funicle, four bifurcations may be counted, and these branches again divide. The subdivisions give about sixty-four branchlets in the entire frond, subject to some variation from the inconstancy of the subdivisions.

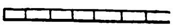
Cellules short straight narrow, inclined to the axis at an angle of about 30°; nearly one half the length of each cellule being free: length of cellules equal to about four times their diameter; the denticles acute, or acutely rounded, varying in the same stipe from about twenty-six to twenty-eight in the space of an inch; apertures making an angle with the axis of about 90°; cell-partitions obscurely marked, and traceable nearly to the back of the stipe. At the base of the branches the cellules are less developed, and sometimes appear as simple undulations of the margin.

This species is very distinctive in its features, both as to mode of growth and manner of bifurcation, as well as in the form and character of cell-denticles. In the first subdivision of the funicle and stipes, it might be mistaken on cursory examination for *G. Logani;* but the divergence of the first division is always less, and the second subdivisions always diverge at a different angle, while the branching of the stipes forms a very distinctive feature. The specimens examined show no evidence of ever having possessed a central disc. The substance of the stipe has an appearance of being more flexible than in any other species, though this character may be varied with the condition of preservation or the nature of the imbedding material. Under a lens, the axis and principal branches are rounded, with a thin corneous expansion or alation on each side, representing in a degree the central corneous cup or disc of other species.

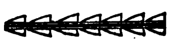
In this species, the branches are sometimes compressed vertically (or in the direction from the celluliferous face to the back of the stipe), to such a degree as to give an apparent double serrature, or a celluliferous face on each side. In this condition, the cell-apertures are at right angles to the direction of the axis, or sloping a little backwards, with the extremities somewhat rounded. When the celluliferous side, thus compressed in the direction of the cellules, is uppermost on the surface of the shale, a line may sometimes be traced across the branch, joining the upper edges of the serratures, and being in fact the continuation of the cell-margins flattened against the stipe, while the extremities project on either side.

In this way we have a great variety of aspects: the smooth surface of the branch, with minute striations upon the outer side; the inner side, when not compressed, having cellules showing as indented lines across the surface (1); the double serration produced by a greater pressure in the same direction, or with the back of the stipe uppermost (2); again, as the branch is gradually turned around, these serratures disappear from one side, and become more prominent upon the other (3), finally showing their full breadth as the branch is compressed in its transverse or lateral direction.*

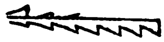
1



2



3



The specimens examined are in a finely laminated greenish-black shale.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS FLEXILIS, Hall.

PLATE X.

3. A fragment of slate preserving more than half of a frond, and showing the folding and crossing of some of the branches.
4. A fragment preserving parts of three individuals, the extremities of the branches all broken off.
5. The central portion of the frond of another individual.
6. Separated branches preserving the cellules in unusual perfection.
7. An enlargement of the centre of the frond, showing the short radicle and the usual mode of branching. The central part of the axis is rounded, with a narrow corneous alation at the sides.
8. A bifurcated fragment enlarged: the cellules have been flattened vertically, causing them to be visible in slight indentations on both sides of the axis.
9. A portion of a branchlet enlarged, showing one part compressed laterally, with the cellules fully expanded, while the other, on the right hand, is gradually twisted so as to show only the back of the branchlet.

Formation and Locality.—Quebec group; Point Lévis.

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* These illustrations of the effects of pressure upon the cellules were given in the Report of the Geological Survey of Canada for 1857.

GRAPTOLITHUS RIGIDUS, Hall.

Plate XI, figures 1–5.

(G. RIGIDUS, Hall: *Geological Survey of Canada*, Report for 1857, page 121.)

Description.—Frond multibrachiate, composed of numerous slender branching stipes, equally disposed on the two sides of their origin. Radicle minute: funicle short, being a little more than one tenth of an inch in length, dividing at the two extremities, the divisions diverging at an angle of 115°; each stipe again bifurcating at least five times, following the principal axis, and occasionally six times in mature individuals; the principal branches again bifurcate twice or three times before reaching their termination.

In the first bifurcation of the stipe, (or second from the radicle,) the angle of divergence is about 78°, and in the second about 60°; while the succeeding divisions diverge at a less angle, and become somewhat curved. In one of the stipes beyond the first division (making one eighth of the entire frond) we are able to count fifteen bifurcations; giving eighteen branchlets to a secondary division of the stipe; or 18 × 8, = 144 in an entire frond, if uniformly branched as in the one examined.

Stipes and branches slender, cylindroid exteriorly, rigid, nearly uniform in width to the third bifurcation; all the measurements from the base giving about four hundredths of an inch diameter upon the outer side or back of the branches. A single specimen, which is apparently the upper side of the stipe, is nearly twice as wide as the above, and preserves a part of the solid axis: this is replaced by iron pyrites.

None of the specimens exhibit well-defined cellules below the last bifurcation, though some of the branches are obscurely undulating or denticulate on one side; but the specimens examined do not admit of a satisfactory determination of these characters.

The impossibility of tracing any evidence of cellules upon any part of the frond below the last bifurcations, suggests the possibility that this species was not celluliferous except at the extremities of the stipes or branches. In most of the specimens examined, these celluliferous parts have probably been broken off; since it is evident that the whole frond has been subjected to maceration, and even the stronger parts are often broken. The regularity of bifurcation is a remarkable feature, and furnishes a character by which even fragments of the species can be readily distinguished; smaller fragments may be known by their rigid wiry appearance.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS RIGIDUS, Hall.

PLATE XI.

1. A fragment preserving the centre and principal branches.
2. A larger specimen, showing the principal ramifications of the branches. This and the preceding specimen show only what appears to be the non-celluliferous portion of the frond.
3. The extreme parts of some branchlets laterally compressed, showing the celluliferous parts of the frond.
4. An enlargement of one of the branchlets of fig. 3.
5. A strong branch with part of the branchlets, showing the lower side or non-celluliferous portion of the frond.

Formation and Locality.—Quebec group; Point Lévis.

GRAPTOLITHUS ABNORMIS, Hall.

Plate XI, figure 6.

(G. ABNORMIS, Hall: *Geological Survey of Canada*, Report for 1857, page 117.)

Description—Frond consisting of numerous slender bifurcating stipes, bilaterally arranged. Radicle minute; funicle long, bifurcating on each side; distance between the bifurcations one third of an inch; the divisions diverging at a little less than a right angle, while the inner subdivisions (or those adjacent to the radicle), after the second subdivision, diverge at right angles to the funicle. Stipes branching several times, one division showing four bifurcations beyond that of the funicle, giving ten branches for the quarter, or forty for the whole frond: stipes and subdivisions sub-cylindrical, being rounded on the lower side, grooved in the centre upon the upper side, and curving at the bifurcations: the width from one to two hundredths of an inch; free from cellules to the fourth division, counting that of the funicle as the first division. The stipes and branches maintain nearly the same dimensions throughout their entire length. Outer divisions apparently celluliferous. Cellules obscure, marked only by undulations upon the margin of the branches.

This species, in its general aspect, resembles *G. Logani* and *G. flexilis*; but differs in important particulars. The funicle is more slender, and nearly twice as long as in either of those species; the divisions of the funicle makes a lesser angle, and the divisions of the stipe near the base are quite different. In the outer subdivisions it approaches in some degree to *G. flexilis*, the stipe being always more curved in its divergence at the bifurcation. The absence of cellules on all of the lower divisions of the stipe distinguishes this from any other species known to me at the present time, except *G. rigidus;* from which it differs in the manner of bifurcation and in the long slender funicle.

In the specimen before me there is a slight dissimilarity in the mode of branching on the two sides; but this relates only to details, and the specimen is imperfect, showing one of the main divisions, and only a small part of the other.

EXPLANATION OF FIGURE OF GRAPTOLITHUS ABNORMIS, Hall.

PLATE XI.

6. A fragment of slate preserving the centre and the branches on one side to beyond the first bifurcation. The other side is imperfect, and apparently less developed.

Formation and Locality.—Quebec group; Point Lévis.

GRAPTOLITHUS RICHARDSONI, Hall. (n. s.)

Plate XII, figures 1–8.

Description.—Frond consisting of strong sub-linear branching stipes, the number from their origin unknown; branchlets diverging at an angle of about 15°, and measuring in their transverse diameter about five hundredths of an inch; the vertical diameter from ten to fifteen hundredths of an inch. The test appears thick and somewhat striated; the cell-partitions often strongly marked; the common body occupying less than one fourth the width of the stipe. Cellules long and narrow, curving upwards, making an angle with the axis of from 25° to 35°; from four to six times as long as the width of the aperture, one fourth of the length or less being free: the angle of the aperture with the axis is about 140°; cell-denticles obtuse or obtusely pointed, eighteen or nineteen in the space of an inch.

The separated stipes of the species, when not branched, resemble those of *G. octobrachiatus*, but the cellules are more inclined, making a less angle with the axis, while the angle of the aperture is much greater. In the branching specimens, we have a character which distinguishes it from any other species.

The specimens examined have the cellules partially or entirely filled with iron pyrites, or other mineral matter, giving a nodose appearance upon the surface; while the back of the specimens, when vertically compressed, is likewise nodose. We are not able to associate this form with the others according to the rule which we have adopted of commencing with the two-stiped forms, and thence going on successively to the more complex, or subdivided forms. It is probable however that this one, in its normal condition, had a form and mode of growth similar to *G. flexilis* and *G. rigidus*, but was of much stronger habit in all its parts.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS RICHARDSONI, Hall.

PLATE XII.

1. A fragment of slate, preserving a stipe, with six branches in its apparent continuation, and impressions of two others in the intermediate space; two of these again bifurcating.
2. A fragment preserving several branchlets, which are compressed in different directions, showing the sides and apertures of the cellules.
3. An impression of a bifurcating fragment, the cellules of which were filled with mineral matter and vertically compressed.
4. A fragment of a branch laterally compressed.
5. The impression of a bifurcating branch where the cellules are somewhat obliquely compressed, and partially filled with mineral matter.
6. A fragment enlarged, giving a lateral view of the cellules.
7. An enlargement from an impression of a branchlet which was obliquely compressed, having the cellules filled with mineral matter.
8. Enlargement of a fragment where the cellules are filled with mineral matter and vertically compressed.

Formation and Locality.—In the shales of the Quebec group; three miles above the river Ste. Anne.

GRAPTOLITHUS RAMULUS, Hall. (n. s.)

Plate XII, figures 9, 10.

Description.—The specimen described consists of a small branch showing two bifurcations: the substance is extremely thin and much compressed in soft finely laminated shale.

Stipe and branches slender, test thin, greatest width about four hundredths of an inch; width of branches half as great. The common body occupies nearly one half the entire width of the stipe: branches diverging at an angle of 40° to 50°.

Cellules short and comparatively broad, inclined at an angle of about 25°, free for more than one half their length; the length of cellules about two and a half times that of the aperture: margin of the aperture making an angle of about 140° with the axis: denticles or cell-extremities short and obtuse; about twenty-eight in the space of an inch.

This species, in its mode of branching, form, and proportion of cell-denticles, differs from any other examined. It has a slight resemblance to *G. flexilis*.

EXPLANATIONS OF FIGURES OF DENDROGRAPTUS RAMULUS, Hall.

PLATE XII.

9. A small bifurcating branch.
10. An enlargement of fig. 9, showing the form and extent of the cellules.

Formation and Locality.—Quebec Group; Point Lévis, below the village, in a loose mass of shale.

GENUS DIPLOGRAPTUS, McCoy.

Diprion, Barrande; *Petalolithus*, Suess.

Characters.—Frond simple (or compound?). Stipes simple, flattened or quadrangular; sides parallel or sub-parallel. Cellules arranged in a single series on the two sides of a double central axis: cellules oblique to the axis, the cell-apertures opening towards the apex; cell-denticles prominent, often mucronate.

These forms are known only as simple stipes, which are supposed to have grown from a fixed root. From analogy with those which I have designated *Retiograptus*, I conceive they may have grown also in a compound form, proceeding from a central axis.

The genera *Retiolites*, *Retiograptus*, and *Phyllograptus* are, in some of these characters, similar to *Diplograptus;* and some of the latter have been included under this designation. The mode of increase and arrangement of the cellules in those genera presents important differences; and I would propose to restrict the term *Diplograptus* to such forms as are included in the above description, or those where the arrangement and growth of cellules are similar to those of *G. pristis*, *G. palmeus*, and *G. pristiniformis*.

The paucity of species and of individuals of this type is a remarkable feature in the collections from the Quebec group. It has scarcely been possible to find specimens for a proper illustration of the spec es.

DIPLOGRAPTUS PRISTINIFORMIS,* Hall.

Plate XIII, figures 15–17.

(GRAPTOLITHUS PRISTINIFORMIS, Hall: *Geological Survey of Canada*, Report for 1857, page 133; *Geology of Canada*, 1863, page 955. FUCOIDES DENTATUS: Brongniart, *Histoire des Végétaux Fossiles*, vol. 1, p. 70, 1828.

Description.—Stipe flattened simple sub-linear, celluliferous on the two sides, narrower at the base, obtuse, showing an extended slender radicle, gradually expanding above and obtaining its full width (about eight hundredths of an inch) within half an inch from the base. Cellules narrow, closely arranged; the free extremity sometimes acute, sometimes obtusely rounded; inclined to the axis at an angle of less than 20°; from six to eight times as long as wide, a little more than one third of their length free: angle of the aperture with the axis very variable, depending on the direction of the compression. About twenty-eight cellules in the space of an inch. Axis strong, often extending considerably beyond the celluliferous portion of the stipe, and sometimes marked by a groove indicating a line of separation.

This species bears some general resemblance to *G. pristis* (Pal. N. Y., vol. i, p. 265, pl. 72, fig. 1); but the stipe is narrower, and the cellules narrower and more closely arranged. In general form it resembles *G. angustifolius;* but in that species the margin is more deeply indented, the cell-denticles are always rounded, and the cellules inclined at a higher angle to the axis.

EXPLANATIONS OF FIGURES OF DIPLOGRAPTUS PRISTINIFORMIS, Hall.

PLATE XIII.

15. A fragment of a stipe, showing the usual form and proportions of the best-preserved specimens.
16. A smaller individual, with the mid-rib or axis extending beyond the body of the stipe.
17. An enlargement from fig. 16, showing more distinctly the form of the cellules.

Formation and Locality.—Quebec group; Point Lévis.

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* This species is probably identical with *Fucoides dentatus*, Brongniart, *ut cit.* See note under *G. bryonoides*, page 84.

DIPLOGRAPTUS INUTILIS, Hall. (n. s.)

Plate XIII, fig. 14.

Description.—Stipes, small and obscure, cellules angular, the free portions extending almost rectangularly to the axis, and produced into submucronate points. The cell-divisions cannot be traced beyond the serratures. The solid axis is slender, and extended beyond the celluliferous portion of the stipe.

These specimens occur as short stipes which preserve an extension of the solid axis, sometimes as great as the celluliferous portion. The distinguishing features are the angular extensions of the cellules, which are nearly equilateral, and sometimes slightly mucronate at their extremities.

This species occurs with *Climacograptus antennarius* and *Retiograptus ensiformis*, and has been observed in only a few specimens.

Formation and Locality.—Quebec group ; Point Lévis.

GENUS CLIMACOGRAPTUS, Hall. (n. g.)

Simple stipes with sub-parallel margins, having a range of cellules on each side ; axis filiform ; cellules short and square ; apertures apparently excavated in the margin of the stipe, and transversely oval or subquadrate ; cell-denticles or appendages, if present, usually on the upper side of the aperture.

Several species of this type at present known are simple stipes with nearly parallel sides, marked by transversely-oval or quadrangular cell-apertures, which, when compressed against the body of the stipe, give the appearance of those forms described by Linnæus and subsequent authors as *Graptolithus scalaris*. In one species, where the stipe apparently preserves its natural proportions, the shorter diameter is about three fifths the longer diameter, and the axis is slender and filiform. In several of the species the axis is seen extending below the base of the cellules; while there is often a more or less extended oblique process from each side at the base, as shown in *C. antennarius* and *C. bicornis*. (Pl. xxiii, figs. 11, 13 ; and pl. A, figs. 13, 15, 16, and 17.)

These species are separated from such forms as *G. pristis* on account of the difference in form of cellules, or rather of cell-apertures, since the limit between the cellule and the body of the stipe is not easily observed in flattened specimens. The species *Graptolithus* (*Climacograptus*) *bicornis* may be considered as the type of the genus; and I conceive that most of those described as *G. scalaris* are veritable species of this genus; among these I would cite pl. iii, figs. 5 and 6, and pl. ii, figs. 14, 15, and also figs. 7 and 8, Barrande, *Graptolites de Bohême*. In the latter figure the axis lies obliquely across the cell-apertures, a feature similar to that shown in plate A, fig. 14, of this memoir. *Graptolithus teretiusculus*, Hisinger, *G. rectangularis*, McCoy, and many of the figures on tab. i and tab. ii of Geinitz's *Graptolithen*, belong to this type.

In suggesting a generic name, I have recognized the original specific designation of Linnæus, *G. scalaris*.

The form of cellules in the peculiar group of which *G. ramosus* may be considered the type, is very similar to *G. bicornis*, and should be separated from *Graptolithus* proper for the same reason, forming a sub-generic group, for which I suggest the name of *Dicranograptus*.

CLIMACOGRAPTUS ANTENNARIUS, Hall.

Plate XIII, figures 11–13.

(GRAPTOLITHUS ANTENNARIUS, Hall: *Geology of Canada*, 1863, page 955.)

Description.—Stipes small, simple, quadrangular, flattened, slightly narrowed towards the base. In their natural condition they have been slender sub-quadrangular tubes, celluliferous on two sides, and having a width when flattened, including the denticles, of thirteen hundredths of an inch. Axis strong, extending beyond the upper extremity of the stipe, and sometimes marked by a longitudinal groove: base obtusely pointed, and having the axis slightly extended in the middle with two setiform processes, one from each side, diverging at an angle of about 60° with the axis, and slightly curved, the two including an angle of from 120° to 125°. Cellules short, nearly twice as wide as long; cell-denticles nearly rectangular to the axis, and frequently inclined; from about twenty-four to twenty-eight in the space of an inch. Surface smooth, and the test extremely thin.

Under this species I have included individuals having the same habit and form, but varying in the distance of the cellules, and presenting much variety of aspect from the different directions in which the stipe has been compressed. In some examples, the margins of the stipes present rectangularly-projecting processes or spinules, which vary from being barely visible to having sometimes a length equal to one third the width of the stipe. Sometimes the margins of the stipes are entirely smooth and straight, and the flattened surface shows indentations produced by the cellules. Often the surfaces are so nearly smooth that these indentations may be readily overlooked. In those flattened stipes where the margins are straight, or where only minute points are visible on the margin, the width varies from nine to eleven hundredths of an inch.

In all well-preserved specimens, whatever the aspect of the cellules, the basal processes or radicles are nearly constant in presence and direction; and the solid axis always projects beyond the upper end of the stipe, and sometimes to the extent of an inch beyond the celluliferous portion. In the extension of the cell-denticles upon the margins of the stipe, in the condition represented in fig. 12, the specimens bear some resemblance to *Retiograptus.*

EXPLANATIONS OF FIGURES OF CLIMACOGRAPTUS ANTENNARIUS, Hall.

PLATE XIII.

11. A young individual, compressed in such a manner that the cell-apertures are not shown upon the margin.
12. A flattened stipe, presenting only the mucronate terminations of the cell-apertures beyond the margin.
13. An older individual, showing the margins of the stipe extending beyond the cell-apertures, while the cellules are visible in the substance of the stipes as darker areas.

Formation and Locality.—Quebec group ; Point Lévis.

GENUS RETIOLITES, Barrande.

Generic characters.—Stipes thin, flat, elongate, triangular, composed of two series of cellules symmetrically arranged in regard to the axis of the figure. The cellules arise from a single internal canal which occupies the central portion of the stipe. The cell-orifices are disposed upon the sides of the triangle, making an acute angle with the axis, and leave no space between themselves.

The above is essentially the description of this genus given by Mr. Barrande.

The species from the Clinton group, which I have referred to this genus is extremely flattened, and it is not possible to determine that it has a triangular form. It possesses a very distinct axis and cell-divisions, which however may sometimes be concealed by the reticulate covering. In the

Canadian species I have not been able to discover a reticulate structure similar to the European species, nor like that from the Clinton group of New York; but there is sometimes an apparent punctate texture, and the test is thickened. Although the axis and cell-divisions are usually distinctly visible, they have not the characters of *Diplograptus*.

The *R. Geinitzianus* of Barrande is found in Bohemia and Saxony at the base of the Upper Silurian, and probably not far from the same horizon as the American species *R. venosus*.

The *R. ensiformis* of the Quebec group holds a much lower geological position, which, together with the difference of structure, leads me to suppose that it may ultimately be separated as a distinct genus.

RETIOLITES ENSIFORMIS, Hall.

Plate XIV, figures 1–5.

(GRAPTOLITHUS ENSIFORMIS, Hall: *Geological Survey of Canada*, Report for 1850, p. 133.)

Description.—Stipe simple, sub-ensiform or elongate-lanceolate, usually broader in the middle and narrower towards the extremities: axis central, with strongly-marked obliquely ascending striæ reaching to the margins. Cellules obscure, apparently corresponding to the striæ; margin usually well defined. Width of stipe, in the largest individuals, sixteen hundredths of an inch; length nearly two and a half inches. Other specimens have a width of one twentieth of an inch, with a length of half an inch. Cellules about twenty-eight in the space of an inch, inclined to the axis at an angle of about 50°, and without any appreciable portion being free. The solid axis is slightly undulating, and the cell-partitions alternate on the two sides of it, thus separating the cellules from each other. In some specimens the base is rounded and obtuse; others show a continuation of the axis, or a central straight radicle. Substance of the test punctate.

All the specimens are extremely flattened, and it is very difficult to distinguish any difference in the opposite sides of individuals. In the best-defined specimen there is a distinct axis with alternate diverging filaments or cell-divisions, which reach to the outer margin, the substance being nearly all removed except this skeleton. In a single specimen, the axis is not strictly defined, and is broader, while the diverging partitions are less strongly marked. This one affords the only evidence that we have of the difference in the two sides of the species, a difference shown in the *R. Geinitzianus* of Barrande.

In the punctate test and undulating axis, we have the characteristics of *Retiolites*, which, as illustrated by Geinitz, shows on one side the cell-partitions reaching to the well-defined axis. The same feature of *Retiolites* is shown in a still stronger degree in the figures of Edward Suess.*

EXPLANATIONS OF FIGURES OF RETIOLITES ENSIFORMIS, Hall.

PLATE XIV.

1, 2, 3. Individuals showing gradations in growth, and slight differences in their proportions.
4. A nearly entire stipe of the largest size observed.
5. An enlargement from the specimen fig. 4.

Formation and Locality.—Quebec group; near Point Lévis.

GENUS RETIOGRAPTUS,† Hall.

Generic characters.—Frond simple ? or compound, consisting of numerous simple stipes in bilateral arrangement, proceeding from an axis or radicle, (or of single stipes growing from their own radicles ?) Stipes elongate-oval, or lanceolate, with longitudinal axis and reticulate structure; margins ornamented with mucronate points. The axis often extends beyond the substance of the stipe in a mucronate tip, and in one species there are long setæ extending from what appears to be the base of the stipes.

I had originally referred the *Retiograptus tentaculatus* to the genus *Retiolites* of Barrande (describing it under the genus *Graptolithus*). A farther examination of its structure, together with that of a species from the shales of Norman's Kill near Albany, induced me to separate them from *Retiolites*, and propose the name of *Retiograptus*. Subsequently an examination of some specimens from the Utica formation from Lake St. John in Canada, revealed a minute compound form which is illustrated in fig. 9 of pl. xiv. Although presenting some slight differences from the other two known species, I conceive it not to be generically separable from them. The specimen is extremely interesting for its illustration of a mode of growth not before known in forms of this kind, and suggests the possibility, if not the probability, that some others of the bi-celluliferous or diprionidian forms may have grown with this compound arrangement of the parts.

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* Ueber Bömischen Graptolithen, von Edward Suess. Naturwissenschaftliche Abhandlungen, IV Band, IV Abth. Tab. VII, 1851.

† A species of this genus has been describe din the third volume of the Palæontology of New-York, Supplement, p. 518; and in the Thirteenth Report on the State Cabinet of Natural History; but no generic description was given.

The stipes of the specimen figure 9, if separated, present an aspect very analogous to those of *Diplograptus* and *Retiolites*, and would not be supposed to have had any different mode of growth. The setiform processes at the base of some of the species may be regarded as an objection to the compound mode of growth; but this feature would offer a still greater objection to regarding those stipes as simple, and as having grown from an independent radix. The three species of the genus now known to me, present some important points of difference one from the other, and there still remains some obscurity regarding the arrangement of the cellules.

These forms are nearly related to the *Retiolites* of Barrande; but the texture of the specimens examined, and the arrangement of the parts, differ so much from authentic specimens of *R. Geinitzianus*, that I have separated them under the above designation.

RETIOGRAPTUS TENTACULATUS, Hall.

Plate XIV, figures 6–8.

(GRAPTOLITHUS TENTACULATUS: (Genus *Retiolites*, Barrande) *Geological Survey of Canada*, Report for 1857, p. 134.)

Description.—Original form of the entire frond unknown. Stipes simple, narrow, very elongate-elliptical when entire, narrower at the base, and gradually expanding above to the middle of their length; where they attain the greatest width, and become gradually narrower above, with the apex obtuse or rounded.

Central axis strong and well defined, extending beyond the stipe a distance equal to half its length: base furnished with two elongate diverging setæ, which extending from the outer edges, gradually curve downwards, and finally assume a direction nearly parallel to the axis. Within these long outer processes, and proceeding from the centre of the base of the stipe, there is an extension of the filiform axis, which sometimes appears in its duplicate character.

Exterior margins reticulate, furnished with a row of hexagonal meshes, separated by slender processes extending from the substance of the stipe, which unite in a continuous filiform border; from this proceed, at about every second reticulation, short setiform spines, which in the middle of the length of the stipe are rectangular to the axis, while nearer to the base and to the apex they are inclined towards the axis in opposite directions. These spines are sometimes on the outer margin of each mesh, and sometimes visible only on every third one. With these rows of meshes, when preserved, the stipe has the appearance of a flattened corneous film with a central axis, which is divided into cellules as in other forms of *Graptolitidæ;* and when the outer meshes are broken off, these cell-divisions project as mucronate points beyond the margin of the stipe. These marginal meshes correspond to the divisions of the stipe marked by the cell-partitions, and might be regarded as showing the limits of the cell-apertures, which have opened obliquely to the transverse direction of the stipe. These meshes or cellules are arranged in the proportion of about twenty-eight in the space of an inch, the stipes being usually nearly three fourths of an inch (the longest one eighty-three hundredths) in length.

We have no evidence that the test is punctate, and it has all the appearance of the ordinary graptolites. The greatest width observed in any stipe, exclusive of the marginal meshes, is seventeen hundredths of an inch. In one specimen the extreme length of the stipe, exclusive of the radicles and extended axis, is seventy hundredths of an inch; and the width, exclusive of the meshes, is fifteen hundredths, and including the meshes, twenty hundredths of an inch.

The specimens examined are all extremely compressed, so that it is impossible to determine any points of structure beyond those presented upon the surface. I do not suppose that the original form has been that of a flattened stipe, but rather of a quadrangular or fusiform sac, perhaps even convex on one side and flat or concave on the other. The cell-divisions are traceable almost to the central axis; and it is the continuations of these that form the reticulation of the margin, and are again produced in setiform spines. It is impossible to reconcile a structure like this with any thing previously described among the *Graptolitidæ;* and though our views of their structure may be somewhat modified by an examination of better preserved specimens, they cannot be united with the ordinary forms; so that while *Retiolites* is separated from *Graptolithus* proper, we may regard this form as equally entitled to generic designation.

EXPLANATIONS OF FIGURES OF RETIOGRAPTUS TENTACULATUS, Hall.

PLATE XIV.

6. An individual of the natural size, with the marginal reticulations nearly entire.
7. The preceding specimen enlarged.
8. An enlargement of another individual, where the marginal reticulations are but partially preserved.
9. An illustration of a compound form of *Retiograptus* (*R. eucharis*), from the Utica formation of Lake St. John. (For a description of this species, see Appendix.)

Formation and Locality.—Quebec group; Point Lévis.

GENUS PHYLLOGRAPTUS, Hall.

Gr. Φυλλον, *folium*, and γραφω, *scribo*.

(PHYLLOGRAPTUS: *Geological Survey of Canada*, Report for 1857, page 135.)

Generic characters.—Frond consisting of simple or compound foliiform stipes, which are celluliferous upon the two opposite sides, the margins having a mucronate extension from each cellule: or consisting of similar forms united rectangularly to each other by their longitudinal axes, and furnished on their outer margins with similar cellules; the whole supported on a slender radicle, or combined in groups.

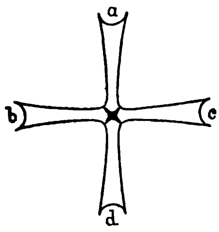
These forms are analogous in structure to *Diplograptus;* but instead of two simple stipes united by their solid axes, we have in the examples illustrated, four stipes united in a similar manner, giving four separate and independant sets of cellules. The cellules have likewise a proportionally greater development, giving a broader form to the stipes than in typical species of *Diplograptus.* These bodies, which usually appear upon the stone as simple leaf-like expansions, may have been attached in groups to some other support; but the forms of most of them, and the character of the projecting radicle at the base, give the same indication of the entireness of the frond that we have in ordinary forms of *Diplograptus.*

Of all the *Graptolitidæ*, these forms furnish perhaps the best illustration of the lesser development of the cells at the base of the axis, and of their gradual expansion above, as far as the middle or upper part of the stipe. Many of them diminish from the centre upwards, and rarely the cells are more developed above the centre, reversing the usual mode, and leaving the narrower part at the base.

When bodies of this form were thrown down upon a muddy sea-bottom, they would become imbedded mainly in two positions. The most common position appears to be that in which the parts retain a vertical and a horizontal direction, as in fig. 1; the lower division or folium *d* would thus become first imbedded; while the folia *b*, *c* would lie in the plane of deposition, and *a* would be the last imbedded. The slaty laminæ separate along the line *b*, *c*, either above or below the folia *b*, *c;* leaving on one side the folia and on the other their impression. If the separation takes place above, then the bases of the cellules of *a* remain; these are directed obliquely downwards towards the base of the stipe. If the separation takes place below the folia *b*, *c*, the cellules of folium *d* are seen directed upwards, or towards the apex of the stipe. These modes of separation would present appearances like figs. 4 and 8, pl. xv; fig. 4, pl. xvi; and figs. 5 and 15, pl. xvi.

The other direction of imbedding would be when the specimens were so deposited that the laminæ rested obliquely to the plane of stratification, as in fig. 2. In this way, from the accumulation of the sediment, they would become compressed, as in fig. 3, until the parts *b*, *d*, and *a*, *c* would approach each other, or come in contact. Lying thus, with the slaty laminæ separating above or below them, they would present the aspects of figs. 6 and 9, pl. xv; and of fig. 8, plate xvi.

1



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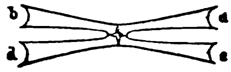

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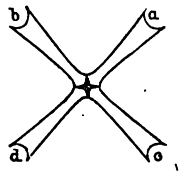

When the parts *b*, *a* are removed, the parts *d*, *c* remain, showing the base of the cellules, as in figs. 4 and 5, pl. xv, and figs. 3 and 7, pl. xvi; while in the examples where the margins only are removed, we have appearances like fig. 9, pl. xvi.

PHYLLOGRAPTUS TYPUS, Hall.

Plate XV, figures 1–12.

(PHYLLOGRAPTUS TYPUS: *Geological Survey of Canada*, Report for 1857, page 137.)

Description.—Stipes robust, composed of four semi-elliptical parts joined by their straight sides. As preserved upon the shale, these bodies are elongate-ovate or lanceolate, broad oval or obovate: cellules about twenty-four, rarely twenty-two, and sometimes twenty-six in the space of an inch, usually obscure at the margin; axis or mid-rib broad, often crenulate or serrate; radicle usually short; in some specimens about half an inch in length being preserved.

The stipe originates from a slender pointed radicle. The cellules near the base are short, coming out almost rectangularly to the axis, or slightly ascending and gradually increasing in width, curving backwards or downwards, and having the aperture sometimes nearly at right angles to the axis: the curvature lessens towards the middle of the stipe, and the line of aperture is parallel to the axis; while above this they are inclined towards the axis, and near the summit they are again nearly at right angles to the axis, but opening in a direction opposite to those near the base. Cell-apertures mucronate by the continuation of the cell-partitions, the mucronate appendages sometimes appearing to be double, as if each angle of the aperture had been thus ornamented.* Central axis linear, from half a line to nearly a line in width. In some examples there is an apparently greater width, which is probably due to a slipping of the test. This central axis is often crenulate from the bases or impressions of cellules of the other division, which is rectangular to that part of the frond preserved.

This species assumes a variety of forms, and, from an examination of specimens of the extremes, they might be regarded as distinct species. After examining several hundred specimens however, I am not able to find constant characters to establish specific differences. The individuals figured represent the principal varieties. I have not thus far observed forms intermediate between the short broad and the elongate-oval ones, but they may be found in larger collections. The number of cellules in entire fronds varies in different individuals from twenty-five to fifty on each side, according to the size and form of the specimen.

The specimens are all compressed, and the rectangular arrangement of the parts of the frond, as seen in *P. ilicifolius*, cannot be seen in these; the evidence of this character being the serratures along the central axis, which are transverse to those of the two sides. The proportions of length and breadth vary extremely; one of the broad forms has a width of five tenths of an inch, with a length of eight tenths of an inch, while a long form is two and an eighth inches in length and six tenths of an inch wide in the widest part.

In a single fragment of the shale containing this species, the number of individual stipes within a small space is so great as to suggest the probability that these have originated from a common axis, as in *Retiograptus*, and have been separated but a little distance from their centre of attachment. With one exception, all these are of small size, and present no greater variation than is observed in the stipes of a single frond of *Retiograptus*, fig. 9, plate xiv.

EXPLANATIONS OF FIGURES OF PHYLLOGRAPTUS TYPUS, Hall.

PLATE XV.

1. An extremely short and broad form of this species, with the axis broad, and showing some remains of the cellules at the base of the separated division.
2. An elongate-ovate form of stipe, with a broad axis, which does not show remains of cellules. Some of the cellules in the upper part of the stipe are filled with iron pyrites.

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* This feature may possibly be sometimes due to the overlapping of two adjacent folia, so as to bring the cell-partitions and cell-denticles near to and parallel with each other, showing a denticle from each one.

3. A form similar to the preceding, showing remains of cellules on the upper part of the axis.
4. An elliptical form of stipe, where two of the divisions have been separated, leaving the bases of two sets of cellules.
5. A broadly-elliptical form, from which two of the divisions and the axis have been removed; showing the bases of the cellules of the folia remaining in the slate.
6. A stipe compressed in the same direction as fig. 3 of the generic illustrations, page 119; with a part of one of the folia removed, but not reaching to the axis. The lines of the cell-partitions appear as if continued across the axis.
7. An elongate-lanceolate form of stipe, which does not show cellules in the line of the axis.
8. An elongate-elliptical and very symmetrical specimen, showing the marks of cellules along the axis, which is unusually narrow.
9. A part of a stipe folded in the manner of fig. 6, the upper portion of one side preserving only the impression of the substance. In the lower part, the cell-markings on the axis should be shown more distinctly.
10. A group of small stipes upon the surface of a piece of shale. These are given in their natural size and in their actual relations to each other.
11. An enlargement of a part of an impression of a stipe which has been flattened in the direction of figs. 6 and 9. A portion of the substance remains, as shown on the left hand; the cellules filled with iron pyrites.
12. An enlarged portion from a stipe, showing the double cell-denticles and corresponding cell-partitions. The narrow spaces on the surface of the figure are more elevated than the wider ones, with a greater thickness of the substance; which I suppose may have been caused by the cell-partitions, which are obliquely compressed, thus showing the cell-denticles. These elevated spaces become gradually narrower towards the axis, in accordance with the form of the cells, as shown in the theoretical figure 10, plate xvi.

Formation and Locality.—Quebec group; Point Lévis.

PHYLLOGRAPTUS ILICIFOLIUS, Hall.

Plate XVI, figures 1–10.

(PH. ILICIFOLIUS: *Geological Survey of Canada*, Report for 1857, page 139.)

Description.—Frond broadly oval or ovate: axis broad; radicle short; cellules from twenty-eight to thirty-two in the space of an inch, varying slightly with the proportionate length of the frond.

The radicle is rarely visible in the specimens examined. The cellules from the base are at first slightly ascending, and gradually curve outwards and downwards, so that the line of aperture is nearly rectangular to the axis. This curvature becomes less in the higher cellules; those of the middle open nearly parallel to the axis, and finally at the summit open in a direction opposite to those of the base. Cell-apertures mucronate, by the extension of the cell-partitions beyond the opening, in nearly their full width; but seen upon the edge, they appear as setiform processes. The test is striated parallel to the cell-apertures, which have a concave outline.

As the specimens lie upon the surface of the shale, the central portion, for about half a line in width, is usually rough, and the broken cellules are clearly distinguishable; while on each side are the semi-oval divisions of the frond, with the cellules spreading from the central axis.

The entire frond in reality consists of four semi-oval or semi-ovate folia, which are joined rectangularly by their longitudinal axes, and in a transverse section present a regular cruciform figure. The expansions of the two sides, when laterally compressed, show distinct cellules with projecting mucronate extensions: those which are vertically compressed have the outer portions broken off in the separated laminæ of slate, and present the bases of the cells; which have been sometimes filled with mineral matter, and distended before being imbedded. In a few instances the cells of the lateral portions are filled in the same manner, appearing as curving conical tubes with the broader extremities outwards.

When the bases of the cellules of the upper or nearest of the folia remain, they are seen to be directed obliquely downwards to the axis; but sometimes in the process of separation these bases are removed wholly or in part, and the bases of the opposite folium are seen below the plane of the two lateral folia, or their impressions, which are spread out on the surface of the slaty lamina: these cellules are then clearly observed to be directed upwards, as we see them from below.

It not unfrequently happens that this broad celluliferous axis is reduced to an undulating line, which results from compression in a direction oblique to the rectangularly-arranged folia, as in fig. 2, page 119, so that the two adjacent parts are spread out, and consequently no central line of cellules would be seen. When these have been divided longitudinally a little on one side of the centre, two sets of cellules are often seen penetrating the stone in oblique directions to the laminæ of shale.

The condition of preservation in several specimens examined is such as to render unavoidable the conclusion which I have given above, as to their mode of growth, however anomalous it may seem.

This species differs from *P. typus* in its thicker substance, proportionally shorter and broader form, and more closely-arranged cellules.

EXPLANATIONS OF FIGURES OF PHYLLOGRAPTUS ILICIFOLIUS, Hall.

PLATE XVI.

1. An individual of the natural size, where the folia *b*, *a*[*] are broken entirely away beyond the axis, leaving the bases of the cellules of two adjacent folia visible except at the upper part of the figure, where two or three of the bases of the other cellules remain.
2. A similar specimen, showing the bases of a set of cellules on each side of the centre, with two or three of those belonging to the broken folium at the base of the figure.
3. An enlargement of fig. 2, showing more distinctly the cellules on each side of the central line, and the small remaining portion at the base.
4. A specimen of the natural size, where one folium is broken away not quite so far as the axis, leaving the bases of its cellules visible.
5. An enlarged figure from a specimen which has been imbedded transversely. Three of the divisions have been broken away, leaving impressions of the lateral ones only, and of the cell-bases, and cell-partitions of the fourth division, which are directed obliquely upwards from the axis and point of view. The lower part of the specimen preserves a portion of the lateral folia, with the bases of the cells of the outer division *a*[*], which are directed towards the axis.
6. An enlargement of a specimen which is imbedded obliquely, or in a direction as if the theoretical figure 10 were vertically compressed, leaving no visible axis. In the lower half of the specimen, the fossil has been separated in the opposite slaty laminæ, leaving only the impression of the opposite side, which also shows no axis. In the upper half of the specimen, the cellules are well preserved, and on the left-hand side the apertures are conspicuous. Enlarged to three diameters.

   It will be observed that the impression is not quite in the same direction as the outline in theupper portion of the figure, owing to the obliquely-compressed folia.
7. A specimen compressed in the same manner as fig. 6; the upper folia have however been separated, except the bases of a few of the cellules in the upper part of the figure, leaving the other two folia imbedded in the shale, and showing the bases of their cellules ascending from the axis. Enlarged to three diameters, as in fig. 6.
8. An enlarged figure of a specimen compressed in the direction first described, without any separation of the parts; from which cause there is no proper axis visible. In this condition, the specimens resemble *Graptolithus folium* of Hisinger, or *G. ovatus* of Barrande.
9. An enlargement of a specimen compressed as in fig. 8, but with the cellules filled, and the margins of the upper two folia broken, showing the cell-openings. (8 and 9 are enlarged to twice their natural size.)
10. A restoration of the form of *P. ilicifolius*, showing the four divisions; which are represented as cut through transversely, exhibiting the cell-cavities.

Formation and Locality.—Quebec group; Point Lévis.

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[*] These letters refer to the illustrative figures on page 119.

PHYLLOGRAPTUS ANNA, Hall. (n. s.)

Plate XVI, figures 11–16.

Description.—Consisting of flattened elliptical stipes, which are sometimes broader above. Radicle minute: margins celluliferous, the cell-apertures furnished with long mucronate extensions. Cellules rising from the axis, expanding in width, and curving outwards and downwards; the curvature diminishing in the middle, while the upper ones are but slightly curved: margins of the apertures regularly concave between the extensions of the cell-partitions, distinctly striated upon the sides parallel to the margins. Axis celluliferous, its width five hundredths of an inch in a specimen of forty-three hundredths of an inch in length, the entire width of the specimen being twenty hundredths of an inch: cellules in the proportion of from thirty-six to thirty-eight in the space of an inch.

This species is shorter in proportion to its length than either of the others; the individuals rarely or never reach the length of half an inch, and vary from one eighth to seven sixteenths of an inch. The test appears to be thicker, and the cellules more distinctly marked than in *P. angustifolius;* while its smaller size and more closely-arranged cellules distinguish it from the other species.

EXPLANATIONS OF FIGURES OF PHYLLOGRAPTUS ANNA, Hall.

PLATE XVI.

11. A specimen with the folia obliquely compressed.

12, 13, 14. Individuals showing some varieties of form. The specimens have all been so imbedded that one of the folia has been torn away in the separated laminæ of shale, leaving an axis marked by the bases of its cellules.

15. An enlargement of a specimen which has one of the laminæ vertically imbedded, and shows the bases of the cells as they recede from the axis. The markings at the sides are from the impressions of the folia, except a small fragment of one remaining on the left-hand side of the figure.

16. An enlargement from a specimen where the two lateral folia remain, showing the bases of the cells of the folium which has been broken off, in the separated laminæ of slate. The surface is distinctly striated.

Formation and Locality.—Quebec group; three miles above the river Ste. Anne.

PHYLLOGRAPTUS ANGUSTIFOLIUS, Hall.

Plate XVI, figures 17–21.

(PH. ANGUSTIFOLIUS, Hall: *Geological Survey of Canada*, Report for 1857, page 139.)

Description.—The stipes, as seen on the slaty laminæ, are elongato-elliptical or elongato-lanceolate, being usually a little broader near the base. Radicle scarcely visible: margins celluliferous; cellules about twenty-four in the space of an inch (rarely twenty-six, while one short broad form shows twenty-eight); cell-apertures with an elongate triangular denticle, which is mucronate at the extremity: the denticle is once and a half as long as the width of the cell. Central axis from three to four hundredths of an inch in width, obscurely indented by the cellules of the other divisions of the frond.

This species differs from either of the preceding in its narrow and elongate form. The specimens are numerous, but being for the most part on slaty laminæ which are extremely compressed, they preserve scarcely any substance; a mere outline, with a more brilliant surface than the rest of the rock, being almost the only remaining characterby which they are recognized. In a few individuals the test is better preserved, showing a moderate thickness. The cell-margins on the upper side are less extended on the cell-partitions than in the preceding species; while on the lower side they are equally or more extended, giving a form of aperture different from that of the other species, and a different denticle.

EXPLANATIONS OF FIGURES OF PHYLLOGRAPTUS AUGUSTIFOLIUS, Hall.

PLATE XVI.

17. A small and comparatively wide specimen, with a distinct linear axis, but without evidence of cellules.

18. A more elongate specimen, with distinct axis, with a darker line in the centre.

19, 20, 21. Varieties of form and proportion. The specimen fig. 21 is the largest observed.

This species is placed under *Phyllograptus* from its similarity in form to others of the genus, although evidence of the quadruple division has not been established. The want of parallelism of the margins, and the subelliptical form would, I conceive, be sufficient to remove it from the genus *Diplograptus*.

Formation and Locality.— Quebec group; Point Lévis.

Genus DENDROGRAPTUS, Hall.

Gr. *δενδρον*, *arbor*, and *γραφω*, *scribo*.

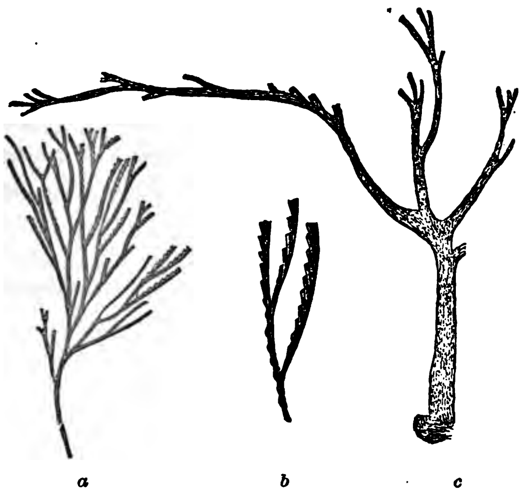
Generic characters.—Fronds simple or aggregate, consisting of a strong footstalk, which is sometimes furnished below with a distinct root or root-like bulb, and above is variously ramified, and subdivided into numerous branches and branchlets, which are but slightly divergent; the whole producing a broad spreading shrub-like frond; (fronds sometimes flabellate ?). Branches celluliferous on one side: cellules appearing sometimes as simple indentations on the surface, and sometimes distinctly angular, with the denticles conspicuous. In some specimens the cellules are indicated by prominent pustule-like elevations, arranged along the centre, or in subalternate order on one face of the branch. Substance of the stipe and branches corneous, solid or tubular: surface striated.

These bodies present specific distinctions in the strength of the stipe or stem, in the mode of bifurcation and number of branches, in the character of the surface, and in the general form of the frond. The celluliferous side usually adheres to the stone, and we perceive only some simple undulations or unequal thickening of the back of the branches. Often the branches have an alation on one side, like a thin pellicle flattened and extended along the more solid axis. The radix or radicle consists of an expansion of the footstalk, and in one species appears like a flattened bulb or disc, of irregular form. The footstalks, when well preserved, are marked by interrupted longitudinal striæ, and the non-celluliferous faces of the branches are variously striated, the striæ in most instances being unequal or interrupted in their course.

In the study of the fossils of this general character, I have indicated the species from the Potsdam sandstone of the Mississippi valley as the typical form of the genus. In this one, the cell-denticles are quite conspicuous and distinctly angular; while in some of the species from the Quebec group, the form of the cell-denticles is obscure, and in others it is shown only as a round or elliptical pit or pustule, depending on the condition of preservation. These differences in the form of the cellule lead me to suppose that a farther subdivision of this group may become necessary; but in the condition of the specimens in the collection before me, I do not feel justified in attempting to do this at the present time.

There is likewise a gradation in the mode of growth among the species, by which there is an apparent transition from the form of *Dendrograptus* proper, to those similar to *Dictyonema*. I have thought it necessary to separate two forms of the latter type under another designation.

The following figures, already published in the Geological Report of Wisconsin, illustrate the character of the species of this genus from the Potsdam sandstone.



Dendrograptus Hallianus, Prout.

a. A portion of the frond, of the natural size.
b. An enlargement of one of the branchlets, showing the cellules.
c. The main stipe and some of the principal branchlets, natural size. There is an expansion or protuberance at the base or radicle, one side of which is broken off.

Dendrograptus flexuosus, Hall. (n. s.)

Plate XVII, figures 1, 2.

Description.—Frond broadly expanding. Stipe short, flexuous, branching near the base : branches somewhat regularly bifurcating, the divisions sub-equal in strength and equally diverging. Stipe and branches flattened, (round in their original form,) very gradually diminishing towards their extremities, flexuous, the margins of the lower ones scarcely undulating; the upper ones more distinctly undulating, and sometimes showing the cell-denticles when viewed upon the non-celluliferous side. Cellules long, narrow, extremities free : cell-denticles angular, about thirty-three in the space of an inch.

This species is less robust than *D. fruticosus*, the stipe more flexuous, the branches proportionally broader, their divergence more equal and at a greater angle, giving a wider expansion to the frond. The branches are not so distinctly undulated by the projection of the cells, and whenever these are visible, the form of the aperture or cell-denticle is a distinguishing feature.

In a specimen of coarse greenish or olive shale, which contains this species, we find also a few fragments of graptolites, among which we recognize *G. bryonoides;* and in another specimen of coarse brown shale, we find it associated with *Phyllograptus typus* and *Dendrograptus fruticosus.*

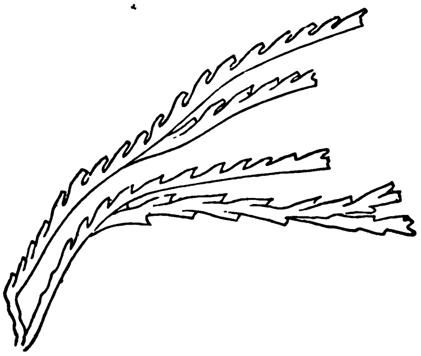
EXPLANATIONS OF FIGURES OF DENDROGRAPTUS FLEXUOSUS, Hall.

PLATE XVII.

1. A small frond of the natural size.
2. A part of a larger frond.

The characters of the cellules and denticles referred to in the description, are derived from some branchlets of the specimen figure 2, which show these features in a very satisfactory manner. The illustration was unintentionally omitted from the plate, and is given in the accompanying figure.

3



3. An enlargement of some of the branchlets of *Dendrograptus flexuosus.*

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS DIVERGENS, Hall. (n. s.)

Plate XVII, figures 3, 4.

Description.—A fragment of a frond of this species shows a flexuous stipe of moderate strength, with slender bifurcating branches, the divisions numerous and widely diverging: cellules arranged in alternating order on the opposite margins of one face of the stipe; non-celluliferous face very obscurely striated.

This species differs from all the others in its regular bifurcation, and in the wide divergence of the branches. The specimen is extremely compressed, and the cellules are only determined by indentations in the shale. It occurs in the same shales with *D. erectus*, *Graptolithus Logani*, *G. quadribrachiatus*, *G. denticulatus*, *G. arcuatus*, *G. Bigsbyi*, and others.

EXPLANATION OF FIGURES OF DENDROGRAPTUS DIVERGENS, Hall.

PLATE XVII.

3, 4. A specimen of natural size, and an enlargement of the same.

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS STRIATUS, Hall. (n. s.)

Plate XVII, figures 5–6.

Description.—Frond numerously branched, spreading. Stipe below the branches unknown. Branches cylindrical, tubular, substance thick and strong: branches and branchlets moderately diverging; non-celluliferous side finely striated longitudinally; striæ continuous, gently undulating. Celluliferous face striated: cellules minute, arranged in an alternating series, or in an undulating line, upon one face of the branches. The indentations left in the shale give an appearance as of a single linear range of cellules. Cellules in the proportion of thirty-six to an inch.

This species is readily distinguished by its striated surface. In mode of branching it resembles *D. erectus;* but differs in the striæ, and in having cellules on the lower part of the branches. The specimen is in a greenish-olive shale.

EXPLANATIONS OF FIGURES OF DENDROGRAPTUS STRIATUS, Hall.

PLATE XVII.

5. A fragment of a frond, preserving the bases of some of the branches.
6. A portion of the non-celluliferous surface enlarged.

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS ERECTUS, Hall. (n. s.)

Plate XVII, figure 7.

Description.—Stipe strong, elongated, erect, nearly straight. Branches alternate, ascending, and causing at their offset a slight bending or divergence of the stipe: branches bifurcating, branchlets alternating; all very slightly spreading, the stipe maintaining a greater diameter than the branches as far as the eighth bifurcation (in the specimen), beyond which it is broken off. Cellules visible on the branchlets only as slight expansions, causing an undulation on the margins, and in the impressions causing slight indentations on the surface of the matrix. Surface of the stipe and lower part of the branches entirely smooth under an ordinary lens.

This species differs from all others of the collection in the elongated and nearly straight stipe, which maintains its distinction from the branches for a long distance above the base. It differs from the strong stipes of *D. fruticosus* in the almost regularly alternating branches, which are distantly and somewhat equally bifurcated. The stipe appears to have been a strong cylindrical tube of dense corneous texture, and the lower part of the branches have the same character. The compressed specimen is marked along the middle of both sides by a longitudinal groove, which appears to have been produced by the flattening of the stipe. The total absence of striæ, and apparently of cellules, on the stipe and lower part of branches, together with the very slight divergence of the branches, are features peculiar to this species. It occurs in the same association as *D. divergens*.

EXPLANATION OF FIGURE OF DENDROGRAPTUS ERECTUS, Hall.

PLATE XVII.

7. The principal stipe, and bases of some of the branches, of the natural size.

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS FRUTICOSUS, Hall. (n. s.)

Plate XVII, figures 8, 9.

Description.—Frond robust. Stipe strong, rounded below, and sometimes terminating in a root-like expansion, flattened above, and irregularly bifurcating; the branches frequently subdivided, the bifurcations continuing almost to the extremities. Branches and branchlets somewhat rounded and undulating or zigzag in direction, smooth or indistinctly striated on the non-celluliferous side. Cellules in alternating series on the opposite margins of the celluliferous side, and distant about twice the width of the branch; from about thirty-three to thirty-six in the space of an inch; swelling out towards the apertures, and giving the undulating appearance to the branches. Cell-denticles angular or sub-angular, twice as long on the lower slope as on the upper or aperture side. The cellules make an angle with the axis of apparently between 25° and 35°.

This species is abundant in the coarse shales which contain *Phyllograptus typus.* The general aspect is that of a delicate plant, and it requires careful observation to detect the celluliferous character of the branches; the celluliferous side also more frequently adheres to the stone. In the impressions thus left after the removal of the substance of the branch, as well as upon the branches themselves, we see the cellules arranged on the margins in alternating series, but with the apertures opening on the same side.

Whenever the pressure has been upon the non-celluliferous side, and that side is exposed, the evidence of cellules consists of little more than enlargements of the sides of the branches. When a stipe is turned a little on one side, a row of cellules becomes visible; and a further turning of the branch discloses the two series, or the alternating ranges of cellules. The form of the cell-denticle is much influenced by the direction of the pressure upon the branches, and also by the character of the surrounding matrix. The root-like expansion at the base does not appear to have been more solid than the stipe above, and is in appearance not unlike the central discs of the uniserrate graptolites.

EXPLANATIONS OF FIGURES OF DENDROGRAPTUS FRUTICOSUS, Hall.

PLATE XVII.

8. A frond which is apparently nearly entire.
9. A more diffuse form of the same species, with some of the branches broken off.

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS ? (CALLOGRAPTUS ?) DIFFUSUS, Hall. (n. s.)

Plate XVIII, figures 1–3.

Description.—Stipe strong, rigid, gradually decreasing in width at each bifurcation: bifurcations numerous, irregular, the stipe slightly bending at each division, and the branches and branchlets strongly diverging. Substance of the fossil extremely compressed, obscurely corrugated; celluliferous face flattened. Cellules apparently arranged in a single series along the longitudinal centre of the branches in the form of minute indentations, and leaving similar minute pustuliform marks in the impressions of the branches; cellules about thirty-six in the space of an inch.

This species differs from *D. erectus* in the more rigid and more widely diverging branches. It occurs in a dark colored or nearly black shale, associated with *Graptolithus extenuatus*, *Climacograptus antennarius*, *Retiograptus tentaculatus* and *Retiolites ensiformis*.

EXPLANATIONS OF FIGURES OF DENDROGRAPTUS ? (CALLOGRAPTUS ?) DIFFUSUS, Hall.

PLATE XVIII.

1. A portion of a broken frond from near the base. The test is removed in some parts, showing celluliferous markings.
2. A fragment of another specimen with similar cell-markings.
3. An enlargement, showing the cell-apertures. The specimens are extremely compressed.

Formation and Locality.—Quebec group; Point Lévis.

DENDROGRAPTUS GRACILIS, Hall. (n. s.)

Plate XVIII, figures 5, 6.

Description.—Frond diffuse, numerously branched. Branches very slender, extremely elongate and sub-pendulous, celluliferous on one side; the cells are arranged in an apparently sub-alternate order, or have assumed this order during the compression of the specimen. Surface striated: cellules deeply indenting the margin of the branchlet, and the outer margin furnished with a mucronate extension.

This species is well marked by its extremely slender branches, which are distinctly serrated, while one side is strongly striated, and the deep indentations give a semi-articulate character to the branches.

Several fragments of this species have been found associated with *Callograptus elegans* and *C. Salteri*, but none more nearly entire than the specimen figured.

EXPLANATIONS OF FIGURES OF DENDROGRAPTUS GRACILIS, Hall.

PLATE XVIII.

5. Two of the larger branches with their sub-divisions, of the natural size.
6. An enlargement from one of the branchlets, showing the striate surface and the deep indentation of the cellules.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

GENUS CALLOGRAPTUS, Hall. (n. g.)

Gr. καλλος, *pulcher*, and γραφω, *scribo.*

Generic characters.—Flabellate fronds, with numerous slender bifurcating branches proceeding from a strong stem or axis. Branches and divisions celluliferous on one side, the opposite side striate; sometimes distantly and irregularly united by transverse dissepiments. The non-celluliferous side sometimes presents a semi-reticulate appearance.

The aspect of these fronds is intermediate between *Dictyonema* and some forms of *Dendrograptus;* but they have not the regular reticulate structure of the former, while the sub-divisions of the branches are quite similar to some of the species of that genus. In the mode of branching and the form of cell-apertures, the present genus is quite different from the typical species of *Dendrograptus.*

The slender branches and minute points which indicate the cell-apertures render it impossible, with the specimens in my possession, to determine satisfactorily the characters of the latter: they appear as simple oval impressions upon the surface of the compressed branches.

It is possible that some of the species of this genus may have grown in funnel-shaped fronds, as *Dictyonema.*

CALLOGRAPTUS ELEGANS, Hall. (n. s.)

Plate XIX, figures 1–4; and Plate XVIII, figure 4.

Description.—Frond broadly flabelliform. Stipe short, flexuous, swelling at the base or root. Branches originating near the root, becoming numerously subdivided, the divisions slightly diverging or nearly parallel, while the whole expands to a somewhat semi-circular form when entire. After the second or third bifurcation the branches become very slender, and continue of nearly equal width. Non-celluliferous face strongly striated, slightly swelling at the cellules: celluliferous face striated; the cellules arranged alternately on the opposite margins, parallel or slightly diverging, and opening in a projecting process or cell-denticle, of undetermined form.

This species differs from *Dendrograptus fruticosus* in its more regularly-branching habit, less divergence of branches in mature specimens, shorter stipe, and more regular flabellate form. It differs from *D. flexuosus* in the more numerous, more slender, and less diverging branches and branchlets. From both it differs in the form of the cells, and in the strongly-striated non-celluliferous face of the frond. In young individuals the branches are often much more divergent, but the striated surface and the arrangement of the cellules correspond in all.

The specimens of this species occur in a fine grayish slate, associated with *Graptolithus nitidus*, *G. constrictus*, *G. bryonoides*, and *G. octobrachiatus*.

EXPLANATIONS OF FIGURES OF CALLOGRAPTUS ELEGANS, Hall.

PLATE XIX.

1. A fragment of a frond, natural size.
2. A nearly entire flabelliform frond. The two shaded lines running nearly vertically through the figure, are due to faults or slips in the slate, causing a slight overlapping of the laminæ, and an interruption of the continuity of the frond.
3. An enlargement, showing the lateral connection of the branches at irregular intervals.
4. A further enlargement of the non-celluliferous side of a bifurcating branchlet, showing the striated surface and a semi-articulate structure.

PLATE XVIII.

4. A fragment which is more lax and spreading, with shorter branchlets than the ordinary specimens, but having similar striæ, and a similar arrangement of cellules.

Formation and Locality.—Quebec group; Gros Maule.

CALLOGRAPTUS SALTERI, Hall. (n. s.)

Plate XIX, figures 5–8.

Description.—Frond spreading or flabelliform above. Stipe below the branches and base, unknown. Branches numerous, undulating, bifurcating: divisions very little diverging; branches closely arranged, the space between them being usually less than the width of the branch. Non-celluliferous face smooth, or obscurely and interruptedly striate; celluliferous face with the cellules alternately on opposite margins, producing swellings of the branch at these points, and an undulating or tortuous direction. A few of the branches astomose, or an are sometimes connected by a short transverse bar of the same width as the branch. This does not appear to be a constant character.

This species has the same general form as *C. elegans*; but the branches are wider and less diverging, and obscurely or not at all striated. The zig-zag direction of the branches forms also a distinguishing feature. The stipe, which is not preserved in the specimens examined, was probably short, branching from near the base. This species occurs with *C. elegans* and its associated graptolites mentioned above.

EXPLANATIONS OF FIGURES OF CALLOGRAPTUS SALTERI, Hall.

PLATE XIX.

5, 6.	Fragments of two distinct fronds; one showing the celluliferous side, and the other the non-celluliferous side.
7.	An enlargement from the non-celluliferous side, showing a few transverse dissepiments at irregular intervals. The figure has the same degree of enlargement as fig. 3 of *C. elegans*.
8.	A farther enlargement of a bifurcating branchlet, showing the cell-apertures.

Formation and Locality.—Quebec group; Gros Maule.

GENUS DICTYONEMA, Hall.

Gr. δικτυον, *rete*, and νημα, *filum*.

(DICTYONEMA, Pal. N. Y., vol. ii, p. 174, 1852, and *Geol. Survey of Canada*, Report for 1857, p. 142. GRAPTOPORA, Salter, Proc. Amer. Assoc.; Montreal, 1857.)

Generic characters.—Fronds consisting of flabelliform or funnel-shaped expansions (circular from compression), composed of slender radiating branches, which frequently bifurcate as they recede from the base. Branches and subdivisions united laterally by fine transverse dissepiments; exterior of branches strongly striated and often deeply indented; inner surface celluliferous or serrate, as in *Graptolithus*.

The general aspect of the species of this genus is like that of *Fenestella*, both in the form of the fronds and bifurcation of the branches. Some of the species have heretofore been referred to that genus, and others to *Gorgonia*. They may be known from either of these genera by the striated and serrated corneous skeleton, and by the absence of round cellules; which latter character, with a calcareous frond, marks *Fenestella*.

DICTYONEMA IRREGULARIS, Hall. (n. s.)

Plate XX, figures 1, 2.

Description.—Frond spreading, diffuse. Branches lax, frequently bifurcating; bifurcations unequal; branches equal to one half the usual width of the interspaces, or a little less; connecting filaments generally slender, expanding at their junction with the branches. Fenestrules extremely irregular in form and proportions, varying from a width greater than the length, to a length three or four times as great as the width; those with a length and breadth nearly equal, often appear hexagonal. Near the base of the frond, the fenestrules are sometimes elongate and triangular. Cellules undetermined. Surface without distinct organic markings. Branches arranged in the proportion of from twenty-five to twenty-eight in the space of an inch.

This species is much smaller than either of the others, scarcely equalling in dimensions the *D. gracilis* of the Niagara group, from which it differs in its more irregular form and diffuse habit. In one specimen there appear to be some identations upon the stone, indicating minute cellules, but they are too obscure for satisfactory determination. This species has been seen only in small fragments: the entire frond is unknown.

EXPLANATIONS OF FIGURES OF DICTYONEMA IRREGULARIS, Hall.

PLATE XX.

1. A fragment from near the base of a frond.
2. A fragment from the outer portion of the frond.

Formation and Locality.—Quebec group ; Point Lévis.

DICTYONEMA ROBUSTA, Hall. (n. s.)

Plate XX, figures 3, 4.

Description.—Frond large, spreading, extremely robust. Branches wide, strong, bifurcating: bifurcations slightly diverging, the interspaces about the same width as the branches. Fenestrules large, elongated; the length from seven to nine tenths of an inch, and the breadth from one twelfth to one seventh of an inch. The transverse connecting filaments comparatively slender: cellules not determined. Surface smooth or obscurely striate.

The specimens of this species before me do not admit of a more complete diagnosis than that above given. It differs from any other species known to me in the great strength of the branches, and in the very elongate fenestrules; while the dissepiments or connecting filaments are usually comparatively slender. The divisions of the branches diverge but little, and the frond does not appear to have been abruptly expanded. It occurs on the hard shales with *Graptolithus rigidus*.

EXPLANATION OF FIGURES OF DICTYONEMA ROBUSTA, Hall.

PLATE XX.

3, 4. Fragments of two different fronds. In some parts of the specimen fig. 3, and in all of fig. 4, the branches are extremely flattened and attenuate.

Formation and Locality.—Quebec group : Point Lévis.

DICTYONEMA QUADRANGULARIS, Hall. (n. s.)

Plate XX, figure 5.

Description.—Frond large, robust. Branches linear, nearly parallel, rarely bifurcating: branches about five hundredths of an inch in width, the interspaces having an average width of eight hundredths of an inch. Fenestrules quadrangular, length and breadth usually nearly equal: connecting filaments nearly as wide as the branches, expanded at their junction with the latter, so as to give an apparent sub-hexagonal form to the fenestrule. Cellules not determined. Surface free from any characteristic markings.

This species is very distinct from the two preceding, and from nearly all other species, by the almost parallel direction of the branches. A fragment an inch and a quarter wide by three inches long, shows not more than four or five bifurcations. The apparently hexagonal form of the fenestrules may be due in part, or entirely, to the breaking or wearing away of the margins of the stipes, or of the connecting filaments, or of both. The short equilateral fenestrules form the most prominent and characteristic feature. It occurs with the other species just described, and with *Graptolithus rigidus*, in the same hard shales.

EXPLANATION OF FIGURE OF DICTYONEMA QUADRANGULARIS, Hall.

PLATE XX.

5. A fragment of a frond, of natural size.

Formation and Locality.—Quebec group; Point Lévis.

DICTYONEMA MURRAYI, Hall. (n. s.)

Plate XX, figures 6, 7.

Description.—Frond very large, gradually spreading from its origin. Branches strong, width from five to eight hundredths of an inch, infrequently bifurcating; divisions little diverging, the interspaces being little wider than the branches. The fenestrules have a width of eight by a length of eleven hundredths of an inch. The connecting filaments are wide at their origin or union with the branch, and slender in the middle; from about one third to one half as wide as the branches. Cellules undetermined. Surface smooth.

This species is associated with *D. robusta.* It is a less robust form, the branches are not more than one half as wide, and the fenestrules not more than one third the length of those in that species, while the connecting filaments are quite as strong. The specimens are extremely compressed, and the character of the cellules cannot be determined.

While the preceding species all have the characteristics of true *Dictyonema*, in none of them has the base been discovered, and the entire form of the frond is therefore unknown. From the strong growth of all of them, and the nearly parallel direction of the branches, we must presume them to be fragments of very large fronds.

EXPLANATION OF FIGURES OF DICTYONEMA MURRAYI, Hall.

PLATE XX.

6, 7. Fragments of two fronds; the figures of the natural size.

Formation and Locality.—Quebec group; Point Lévis.

GENUS PTILOGRAPTUS, Hall. (n. g.)

Gr. *πτιλον, pluma,* and *γραφω, scribo.*

Generic characters.—Frond plant-like, rooted? simple or branching. Branches and branchlets plumose, the pinnules rising alternately on opposite sides of the branches; celluliferous on one face only: branches cylindrical or flattened. Substance corneous, dense; apparently smooth exteriorly, or corrugated by compression, or during fossilization.

In general habit this genus resembles the modern *Plumularia*, and its mode of growth was probably similar. We know at the present time two species, one a slender and delicate form, the other more strong and coarse, and differing in its irregular mode of branching; while at the same time the smaller branches and pinnulæ resemble the other species. The cellules are distinctly confined to one face of the pinnulæ; but whether arranged in a single linear series, or in alternating order, cannot be satisfactorily determined. Both species are in soft shales, associated with *Graptolithus Logani*, *G. quadribrachiatus*, *G. arcuatus*, *G. Bigsbyi*, and others.

PTILOGRAPTUS PLUMOSUS, Hall. (n. s.)

Plate XXI, figures 1–4.

Description.—Frond bi-pinnate, branching. Branches slender, plumose; the axis round and smooth on the non-celluliferous side, and grooved on the opposite side. Pinnules simple or rarely divided, alternate, long and slender, flexuose, rising at an angle of 40° to the axis. Cellules minute, arranged upon one face of the pinnules.

The entire form of this species is unknown: the branches appear to have been rounded, solid, and very gradually tapering. The pinnulæ are slender, linear, maintaining their width to the obtuse extremities: they have sometimes a length of about five eighths of an inch. Near the base they are solid; beyond this they are flattened and slightly rugose (as if from contraction), and preserve very little substance. It has not yet been satisfactorily determined whether the cellules are arranged in a single linear series on one side of the pinnulæ, or in a double alternating series.

EXPLANATIONS OF FIGURES OF PTILOGRAPTUS PLUMOSUS, Hall.

PLATE XXI.

1. A fragment which is three times branched.
2. A slender simple branch.
3. An enlargement from the specimen fig. 1.
4. A further enlargement of a portion of the same; some of the branches showing markings like cell-apertures.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

PTILOGRAPTUS GEINITZIANUS, Hall. (n. s.)

Plate XXI, figures 5–8.

Description.—Frond numerously and irregularly branched. Branches thick and strong, irregularly bifurcating. Pinnulæ broad and strong, closely alternating on opposite sides of the branches. Cellules large, arranged on one face of the pinnulæ: non-celluliferous side smooth, or corrugated from compression.

This species differs from the preceding in its stronger and coarser habit, its more frequent and irregular branching, in the broad flattened branches and the broader pinnulæ, of which there are about six in the space occupied by nine in the other species. The cellules are stronger, and apparently more distant.

EXPLANATIONS OF FIGURES OF PTILOGRAPTUS GEINITZIANUS, Hall.

PLATE XXI.

5. A branching fragment showing the celluliferous side.
6. A fragment which is irregularly branched, showing the non-celluliferous side.
7. A single branchlet of the same species.
8. An enlargement from fig. 5, showing the cell-apertures.

Formation and Locality.—Shales of the Quebec group; Point Lévis.

GENUS THAMNOGRAPTUS, Hall.

Gr. *θαμνος*, *frutex*, and *γραφω*, *scribo*.

(THAMNOGRAPTUS, Pal. N. Y., Vol. III, p. 519,* 1859.)

Generic characters.—Fronds consisting of straight or flexuous stipes (growing singly, or conjoined in groups at the base?), with alternating or widely diverging branches: branches long, simple or ramose, in the same manner as the stipe. Substance fibrous or striate; the main stipe and branches marked by a central longitudinal, depressed line, indicating the axis. Cellules or serratures unknown.

THAMNOGRAPTUS ANNA, Hall. (n. s.)

Plate XXI, figure 9.

Description.—Stipes slender, linear, undulating. Branches filiform, long, flexuous, regularly alternating on opposite sides: the distance between the branches on the same side is about fifteen hundredths of an inch, giving half that distance on the main stipe between the origin of the branches. At the base of each branch, the stipe diverges in the opposite direction, making an angle of 30° with its previous direction. The angle between the stipe and the branch measured on the lower side is about 130°, and on the upper side 80°, showing a divergence of 30° in the direction of the stipe.

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* A description of this genus, with other graptolitic genera, was read before the American Association for the Advancement of Science, at Baltimore in 1858; but the paper was not sent in for publication, and only a newspaper report of it was given.

The branches are flexuous, filiform, and as far as traced, simple ; rounded or somewhat flattened as they occur in the stone. The substance of the stipe or branches does not show cellules ; and the markings are groove-like depressions in the stipe for a short distance below the base of the branches. The test is corneous, black and shining.

This species differs from *T. typus* of New-York, in its less rigid appearance, flexuous stipe, and more diverging branches.

EXPLANATION OF FIGURE OF THAMNOGRAPTUS ANNA, Hall.

PLATE XXI.

9. A fragment of the species, of the natural size.

Formation and Locality.—Quebec group ; three miles above the mouth of the river Ste. Anne.

SUPPLEMENT.

DESCRIPTIONS OF SPECIES FROM THE UTICA SLATE, INTRODUCED FOR COMPARISON AND ILLUSTRATION.

GRAPTOLITHUS FLACCIDUS, Hall. (n. s.)

Plate II, figures 17–19.

Description.—Frond consisting of two slender linear flexuous stipes, which are widely divergent from a small short obtuse radicle. The stipes at their origin are gently ascending, and then curve broadly backwards or downwards, and maintain throughout their entire length a curvilinear direction; stipes cylindrical near the base, and flattened in their extension. Surface smooth, or with striæ so fine as to be invisible under an ordinary lens. The diameter of the stipe varies from two hundredths near its origin, to four hundredths of an inch in the fully-developed parts, maintaining this width to the extremity: more than one half of the width is occupied by the common body. Test comparatively thick. Cellules narrow; from twenty-eight to thirty and near the base sometimes thirty-two in the space of an inch; inclined at an angle of 20° or less to the direction of the axis. Point of the denticle or aperture obtusely rounded, very rarely angular: cellules free throughout their entire length.

This is a very distinct and well-marked species, with slender lax stipes extending four or five inches or more from the radicle. It occurs in large numbers, the stipes lying intertwined among themselves upon the surface of the shale. The cell-denticles are very minute; and near the base of the stipe the surface appears as if marked by small punctured or indented pustules. This pustuliform aspect seems to be due to the strong partition-walls of the cellules, which resist the pressure, and retain nearly their original form, while the adjacent parts become flattened. Farther from the origin of the stipe the whole substance is extremely compressed, and the cellules are only indicated by undulations in the margin of the stipe, which show obscurely the rounded cell-denticle. The cellules are almost always upon the convex side of the curve of the stipe.

The proportions of the stipe are about the same as in *G. tenuis*, Hall, (not Portlock); but that species has the stipes straight and extremely flattened in all the specimens seen. In both species the cell-denticles are rounded, or appear only as slight undulations of the margin; but in *G. tenuis*, the number in the space of an inch is from twenty-two to twenty-four. These, with the other differences, are very distinctive.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS FLACCIDUS, Hall.

PLATE II.

17. A portion of a large fragment of slate, with parts of several individuals upon the surface, and showing the origin of eight individuals in the minute radicles. Some of these are indicated by asterisks on the engraving.
18. An enlargement to three diameters of the radicle and stipe-bases, with the cellules. From the point *a* on fig. 17.
19. A farther enlargement of a portion to show the form of the cellules, and the pustuliform appearances at the base of the divisions between the cellules.

Formation and Locality.—Shales of the Utica formation; Lake St. John, east from Blue Point.

GRAPTOLITHUS QUADRIMUCRONATUS, Hall. (n. s.)

Plate XIII, figs. 1–10.

Stipes consisting of simple quadrilateral tubes, which are celluliferous on the two opposite sides; the plain and the celluliferous sides being of equal width in the middle, or half-way from the base to the apex, where the stipe attains its greatest dimensions; celluliferous sides of the stipe gently increasing in width from the base, with the sides parallel above. The base is narrow and somewhat obtusely pointed below. In what appear to be mature stipes the greatest length is two and a half inches; the width, when flattened and showing two of the four sides, is a little more than one eighth of an inch, exclusive of the cell-denticles. Test corneous, comparatively thick, and without visible striæ. A slender axis marks the centre of the stipe, and rarely extends beyond the apex. The cellules consist of simple notches or transverse slits in the opposite sides, which are slightly indented in the non-celluliferous face, and each angle or sinus produced into a slender, mucronate spine, making a range of spines upon each angle, or four ranges of spines marking the entire length of the stipe; about twenty-two cellules in the space of an inch, the margin or lip slightly projecting.

The specimens of this species occur in great numbers upon the weathered and fresh surfaces of some specimens of the Utica slate. Some are in a well-preserved condition, others are partially preserved, and others consist of moulds or impressions of the stipes. The specimens have been compressed in every possible direction, sometimes parallel to the celluliferous face, giving the more natural expression, or that which is regarded as the more characteristic of the graptolite (fig. 1); others are compressed vertically to the celluliferous sides, so that the plain faces are pressed beyond the margins of the cellules, giving the scalariform character (fig. 3). In other specimens the pressure has been directed against the angles of the stipe, showing one of the plain, and one of the celluliferous sides (fig. 2). The cellules in such examples extend half way across the width of the stipe, and show the spines upon the outer margin; while the spines marking the inner margin are either compressed or broken off (fig. 8), leaving their bases visible along the centre of the stipe. On the opposite margin the mucronate spinules, marking the inner angle of the opposite cellules, are shown, extending outward as far as those on the opposite side, though that half of the stipe is entirely plain with an undulating margin between the spinules. Sometimes on this side the spinules may be folded beneath, and the stipe presents a continuous margin, and has the appearance of a uniserrate graptolite, both characters being sometimes seen in the same individual (fig. 2).

In specimens which are compressed vertically to the non-celluliferous face, the mid-rib or axis is distinctly marked, often throughout the entire length of the individual, as a slender filiform body. The cell-partitions in some specimens are well marked, but in the greater number are obscure; this condition probably arising from the thick outer test of the specimen. The spinules originate in the sinus or angle at the intersection of the lip of the aperture with the body of the stipe.

Some other species besides this have grown as quadrilateral tubes. Those specimens which show an undulated margin with projecting mucronate points or spinules can be of no other form than that which is here described: we have good reason to suppose all those with inequilateral stipes to belong to the same form; and those with deep indentations on one side and without cell-markings, except simple undulations on the other side, are only another phase, depending upon the direction and degree of pressure.

The species under consideration, in its various aspects, illustrates more fully than any other which we have seen, the effects of pressure in different directions. The cellules, in form and in manner of opening upon the surface, differ from such as *Graptolithus pristis*, and appear to be intermediate between those of *G. bicornis*, = *Climacograptus*, and those of *G. ramosus*.

EXPLANATIONS OF FIGURES OF GRAPTOLITHUS QUADRIMUCRONATUS, Hall.

PLATE XIII.

Fig. 1. Part of a stipe compressed in a slightly oblique direction, still showing the cellules on the two sides.
Fig. 2. A stipe compressed more obliquely, so as nearly to obscure the cellules on one side.
Fig. 3. A specimen compressed vertically to the celluliferous side of the stipe.
Figs. 4, 5, and 6. Enlargements from specimens, figs. 1, 2, and 3 respectively.
Fig. 7. Enlargement from a specimen where the solid axis lies near to one side.
Fig. 8. A specimen obliquely compressed, so that the mucronate points at one angle of the cellules of the left side, are pressed through the test, and show on the surface as a range of pustules. The axis is displaced, and seen on one side of the centre.
Fig. 9. A diagram representing a theoretical longitudinal section.
Fig. 10. A transverse section of a stipe with the mucronate extensions of the cell-margins.

Formation and Locality.—Utica slate formation; Lake St. John, east from Blue Point.

RETEOGRAPTUS EUCHARIS, Hall. (n. s.)

Plate XIV, fig. 9.

Frond spreading, nearly flat, consisting of numerous narrow lanceolate elliptical stipes, attached to a common initial point or axis, and bilaterally arranged on two sides of a short funicle, which is four or five times bifurcated on each side.

Stipes varying in proportions, the length being from three to five times the width; axis very distinct, undulating, and its continuation traced from the radicle to the distal extremity, beyond which it extends in a mucronate point. Cell-partitions distinct, alternating, essentially rectangular to the axis, the cellules having their greatest development about the middle of the length of the stipe. Margins of the stipe ornamented by short mucronate points which alternate with the cell-partitions.

Surface of the test smooth or granulose.

EXPLANATION OF FIGURE OF RETEOGRAPTUS EUCHARIS, Hall.

PLATE XIV.

Fig. 9. The frond three times enlarged.

Formation and Locality.—Utica slate; Blue Point, Lake St. John.

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PLATES.

Plates A and B illustrate the structure of the Graptolitidæ as referred to in the Introduction, Chapter I.

Plates I to XXI illustrate the species of Graptolitidæ described in Chapter II and Supplement.

EXPLANATIONS OF PLATE A.

CLIMACOGRAPTUS TYPICALIS, page 57.

See observations on *C.* (*G.*) *bicornis*, etc., pages 27, 28, 30, 45, and 111.

Figures 1 – 8 are enlarged to six diameters.

Fig. 1. A lateral view of the concave side, with the surface entire, showing the form of the cell-apertures.

" 2. A lateral view of the same, showing the entire form of the cell-apertures.

" 3. Lateral view of a fragment where the surface is exfoliated, showing the cell-partitions extending downwards towards the centre.

" 4. A longitudinal section made a little below the exterior surface, showing the cell-partitions extending further towards the interior than in fig. 3.

" 5. A longitudinal section through the centre, showing the cell-partitions reaching to the central axis.

" 6. A transverse section, showing the cell-partitions just within the aperture, and the minute central axis.

" 7. A transverse section made a little lower than in fig. 6, showing the cell-partitions extending across the stipe on one side, and on the other side showing the narrow triangular point near the centre.

" 8. A section made diagonally across a crushed stipe, showing the folding (from pressure) of two cell-divisions on each side of the centre.

" 9. An ideal longitudinal section, showing the form and direction of the cell-partitions and the central axis, (enlarged to twelve diameters).

GRAPTOLITHUS PUTILLUS, pages 27 and 44.

Enlarged to twelve diameters.

Fig. 10. A fragment of a stipe, showing the two ranges of cellules, their form, mode of growth, and the unfolding of the exterior test along the line of the central axis.

" 11. A lateral view of the same fragment, showing the cell-apertures and the flattening of the exterior of the base of the next cellules in advance, and the greater breadth of the cellules at the bases.

" 12. A longitudinal section through the centre of the stipe, showing the double cell-partitions and the double central axis.

" 12 *a.* A transverse section cutting one cellule near the aperture and the other near the base.

CLIMACOGRAPTUS BICORNIS, pages 20, 21.

(*Graptolithus bicornis*, Palæontology of New York, vol. i, page 268, and Geology of Canada, page 200.)

Fig. 13. The lower part of a stipe enlarged to two diameters, showing the bifurcating process and a central node or radicle.

" 14. An enlargement to six diameters of a fragment which preserves in a very perfect manner the border of the cellules, and shows an undulating central axis as well as the median ridge.

" 15. The base of a specimen showing three spine-like processes, (two diameters).

" 16. The lower extremity of a specimen showing a partially developed corneous disc, (two diameters).

" 17. The lower extremity of another specimen, showing a more complete disc or bulb at the base, (two diameters).

EXPLANATIONS OF PLATE A, continued.

CLIMACOGRAPTUS (sub-genus DICRANOGRAPTUS) RAMOSUS, pages 15, 31, 45, 46, and 112.

(*Graptolithus ramosus*, Palæontology of New York, vol. i, page 27, and Geology of Canada, page 200.)

Fig. 18. The lower part of a frond in which the base is entire, with the bifurcation above, (natural size).

" 19. The bifurcating portion, with a part of the simple stipe, showing the cells on one side as they are usually seen when flattened in the slate. On one portion of this there are oval pustules, which is a feature sometimes observed. The opposite side gives the appearance of the cellules when flattened and compressed partially against the aperture, (six diameters).

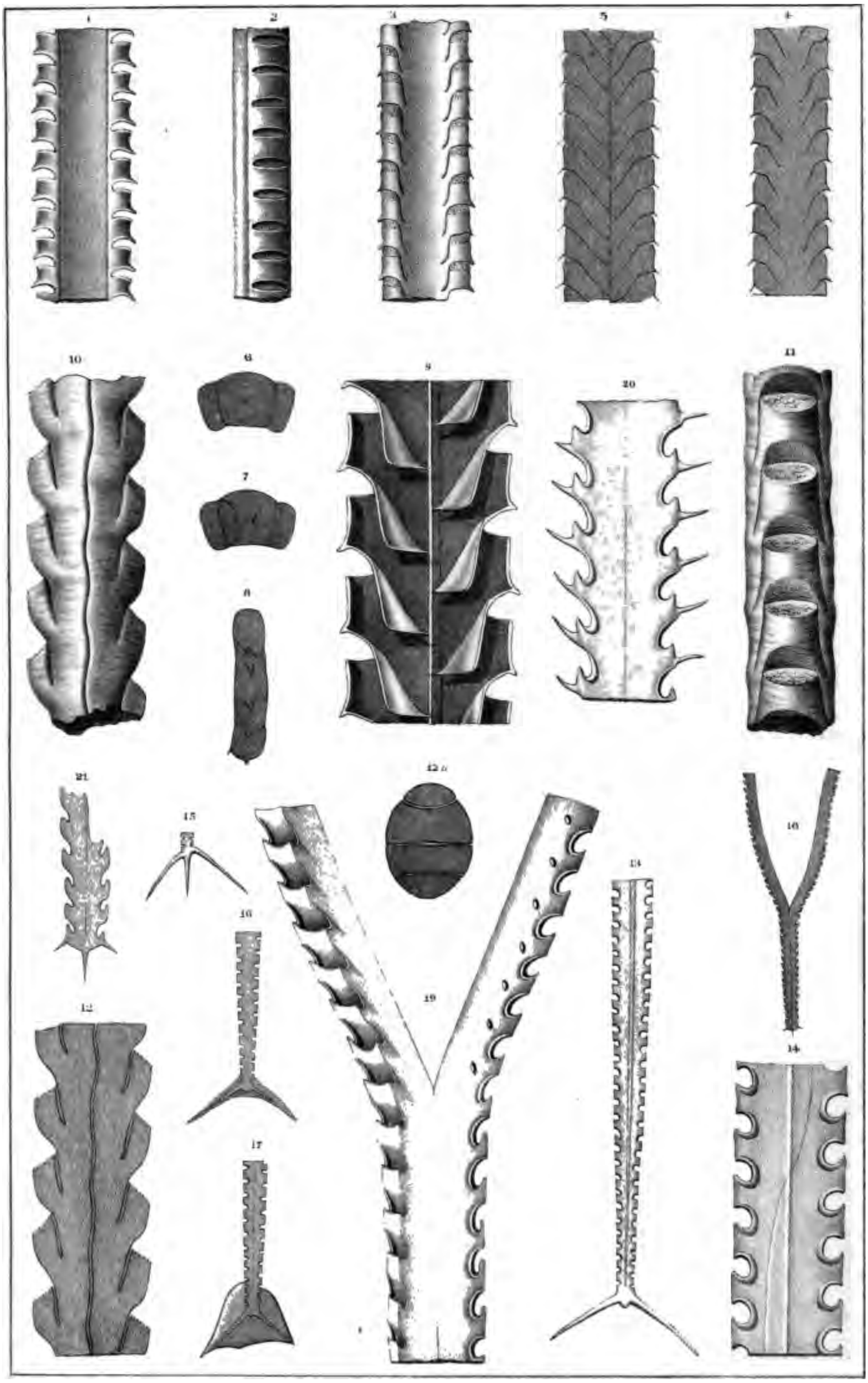
" 20. An enlargement from below the bifurcation, showing the more perfect form of the aperture, with the spines proceeding from the exterior surface above the aperture, (enlarged to six diameters); see page 31.

" 21. A young individual or germ, supposed to be of this species, showing the basal processes and the partially developed cellules at the upper part. See page 34.

Geological Survey of Canada.

Decade 2. Sir W. E. Logan, Director. Plate A.

Graptolitidæ.



R. F. Whitfield Delt. James Hall Descript. [illegible] lith.

EXPLANATIONS OF PLATE B.

Graptolithus Clintonensis, pages 25, 27, 29.

(Palæontology of New York, vol. ii, page 39.)

Figures 1, 2, and 4 are enlarged to six diameters, and figure 3 to nine diameters.

Fig. 1. A fragment from near the base of a stipe, where the cellules are less developed than in other specimens. The cellules are partially filled with mineral matter and have an angular form.

" 2. A lateral view of a part of a mature stipe, showing the form of the cellules, and the recurved extremities causing the apertures to open downwards. The specimen is filled with mineral matter.

" 3. A front view of a part of the same stipe, showing the lateral extent of the cell-bases and the expansion at the aperture.

" 4. A dorsal view of the same, showing a groove which indicates the place of the solid axis.

" 5. A branch of Dictyonema gracilis (page 29), showing the serrated margin indicating cell-apertures; (enlarged six diameters).

Graptolithus Whitfieldi, pages 32, 33, and 36.

Figures 6 – 10 are of natural size; figure 11 is enlarged to two diameters.

Fig. 6. A stipe showing serratures, with a few partially developed reproductive sacs in the upper part.

" 7. A stipe where the sacs are more fully developed.

" 8. A stipe with numerous reproductive sacs, some of which have apparently become dehiscent, and exhibit numerous extremely slender fibres.

(In connection with one of these sacs there are two minute germs, one of them lying beneath the sac, and the other just beyond its outer margin and barely separated from its fibres. See fig. 11.)

" 9. A stipe with a few of the sacs remaining, and the bases of some others which have apparently been broken off. One of these sacs appears to be attached to the axis above the cellules and lying beneath the axis.

" 10. A stipe from which the reproductive sacs have been removed (by maceration), showing only the marginal fibres by which they were attached to the axis of the parent stipe. Some of these remain connected with the axis in its extension beyond the cellules.

" 11. An enlargement of a single sac, from fig. 8, showing the position of the two germs.

EXPLANATIONS OF PLATE B, continued.

GERMS OF GRAPTOLITES.

Figures 12, 13, 14, 16, 17, 18, 19, are germs of Graptolites enlarged to six diameters. (See pages 33 and 34.)

Fig. 12. A germ of a biserrate form, before the cellules have assumed distinctive shape. The axis is extended, and the common body spreads on both sides in the lower part, the cellules embracing the lateral processes, which are seen at the base of most of the diprionidian forms, and extending along one side of the axis above.

" 13. A form similar to fig. 12, a little farther advanced, where the lower cellules have begun to assume their proper form.

" 14. Another form of germ resembling *G. ciliatus;* the ciliated processes are visible beyond the limits of the sac, but the cellules appear not to have assumed definite form.

" 15. A young individual of *G. ciliatus*, (natural size).

" 16. A discoid germ. This may be the central disc of a compound form of Graptolithus.

" 17. A germ showing the common body extended on the two sides of the axis, but without any visible or apparent cellules.

" 18. A germ where the common body or sac is much expanded on the two sides of the axis, and the central portion is apparently becoming more solid.

" 19. A germ where the solid axis is on one side; the species probably belongs to the monoprionidian type.

RETIOLITES VENOSUS, pages 22, 47, 113, and 114.

(Palæontology of New York, vol. ii, page 40.)

The figures are enlarged to nine diameters.

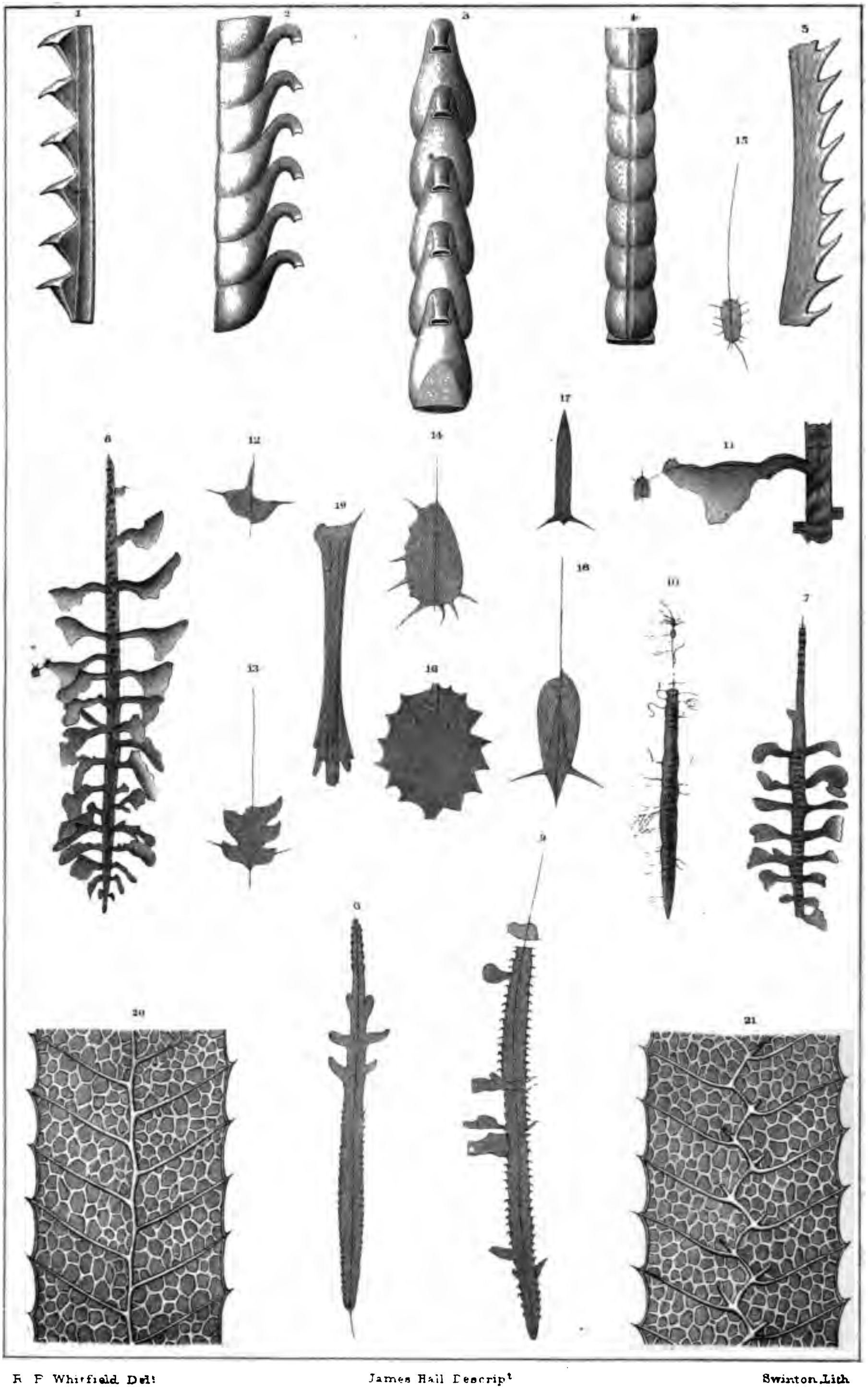
Fig. 20. The exterior of the convex (?) side, showing the external axis and cell-partitions, with the intermediate reticulate texture.

" 21. Another view, apparently from the interior (see page 47), showing an undulating or zig-zag axis, with cylindrical processes extending to the margins, and short, apparently broken processes directed obliquely upwards. The reticulate structure is not essentially different from that of the other side.

Geological Survey of Canada.

Decade 2. Sir W. E. Logan, Director. *Plate B.*

Graptolitidæ.



R. P. Whitfield Delt James Hall Descript Swinton Lith.

EXPLANATIONS OF PLATE I.

GRAPTOLITHUS NITIDUS, page 69.

Fig. 1. A young individual with the radicle and the two stipes.
" 2. The extremity of a stipe enlarged, showing the partially-developed cellules.
" 3. A larger specimen similar in character to fig. 1, showing the pustules at the base of the cellules. The extremities are not quite entire.
" 4. A part of the left side of fig. 3 enlarged, showing the pustuliform elevations.
" 5. An enlargement from fig. 8, with the cellules obliquely compressed and the pustules obscure.
" 6. Two smaller individuals, which, from juxtaposition and similarity, seem as if they may have originated from a common base.
" 7. An impression of a more extended form, proportionally narrower than fig. 3.
" 8. A still narrower stipe, diverging almost rectangularly from the direction of the radicle.
" 9. A well-preserved small individual, enlarged three diameters.

GRAPTOLITHUS PATULUS, page 71.

Fig. 10. A specimen preserving the radicle, and a stipe on one side two and a half inches in length.
" 11. The distal extremity of a larger stipe. Some of the cells are filled with pyrites.
" 12. A short stipe broken off near the radicle, showing the narrow form near the base, and a width beyond greater than in ordinary forms.
" 13. A part of fig. 12 enlarged.
" 14. A part still further enlarged to show the striæ parallel to the cell-apertures.
" 15. An enlargement from fig. 11, where some of the cells are filled with iron pyrites showing their extension almost to the back of the stipe.

GRAPTOLITHUS BIFIDUS, page 73.

Fig. 16. A small specimen from the same fragment of slate with fig. 17.
" 17. An individual of ordinary size.
" 18. An enlargement of the upper part of one stipe of fig. 17.

GRAPTOLITHUS INDENTUS, page 74.

Fig. 20. An individual of the natural size, the continuation of the stipes having been broken off on ode side.

GRAPTOLITHUS EXTENUATUS, page 75.

Fig. 21. A fragment of the stipe, natural size.
" 22. A portion of the lower extremity enlarged ; a part of the specimen retaining the substance of the fossil, and a part being an impression in the slate.

GRAPTOLITHUS CONSTRICTUS, page 76.

Fig. 23. A young individual, natural size.
" 24. An older specimen, the stipe broken off on one side.
" 25. A part of a much more extended stipe, but which is not wider than fig. 23.
" 26. A part of a stipe from Gros Maule.
" 27. An enlargement of the last, showing the form of cells, the cell-denticles or apertures, and the characteristic apparent constriction.

EXPLANATIONS OF PLATE I.

GRAPTOLITHUS NITIDUS, page 69.

Fig. 1. [illegible] individual with the radicle and the two stipes.

[illegible] extremity of a stipe enlarged, showing the partially-developed cellules.

[illegible] specimen similar in character to fig. 1, showing the pustules at the [illegible] the cellules. The extremities are not quite entire.

[illegible] the left side of fig. 3 enlarged, showing the pustuliform elevations.

[illegible] enlargement from fig. 8, with the cellules obliquely compressed and the [illegible] obscure.

[illegible] smaller individuals, which, from juxtaposition and similarity, seem as if they may have originated from a common base.

[illegible] a more extended form, proportionally narrower than fig. 3.

" 8. A [illegible] stipe, diverging almost rectangularly from the direction of the [illegible].

[illegible] A [illegible] small individual, enlarged three diameters.

GRAPTOLITHUS PATULUS, page 71.

Fig. 10. A specimen preserving the radicle, and a stipe on one side two and a half inches in length.

" 11. The distal extremity of a larger stipe. Some of the cells are filled with pyrites.

" 12. A short stipe broken off near the radicle, showing the narrow form near the base, and a width beyond greater than in ordinary forms.

" 13. A part of fig. 12 enlarged.

" 14. A part still further enlarged to show the striæ parallel to the cell-apertures.

" 15. An enlargement from fig. 11, where some of the cells are filled with iron pyrites, showing their extension almost to the back of the stipe.

GRAPTOLITHUS BIFIDUS, page 73.

Fig. [illegible] from the same fragment of slate with fig. 17.

[illegible] ordinary [illegible]

" [illegible] of the [illegible] of one stipe of fig. 17.

GRAPTOLITHUS INDENTUS, page 74.

Fig. [illegible] individual of the natural size, the continuation of the stipes having been [illegible] off on [illegible] side.

[illegible] PTOLITHUS EXTENUATUS, page 75.

Fig. [illegible] natural size.

[illegible] extremity enlarged; a part of the specimen retaining [illegible] and a part being an impression in the slate.

[illegible] CONSTRICTUS, page 76.

Fig. 23. A [illegible]

" 24. [illegible] off on one side.

[illegible] stipe, but which is not wider than fig. 23.

[illegible]

[illegible] the form of cells, the cell-denticles or [illegible] apparent constriction.

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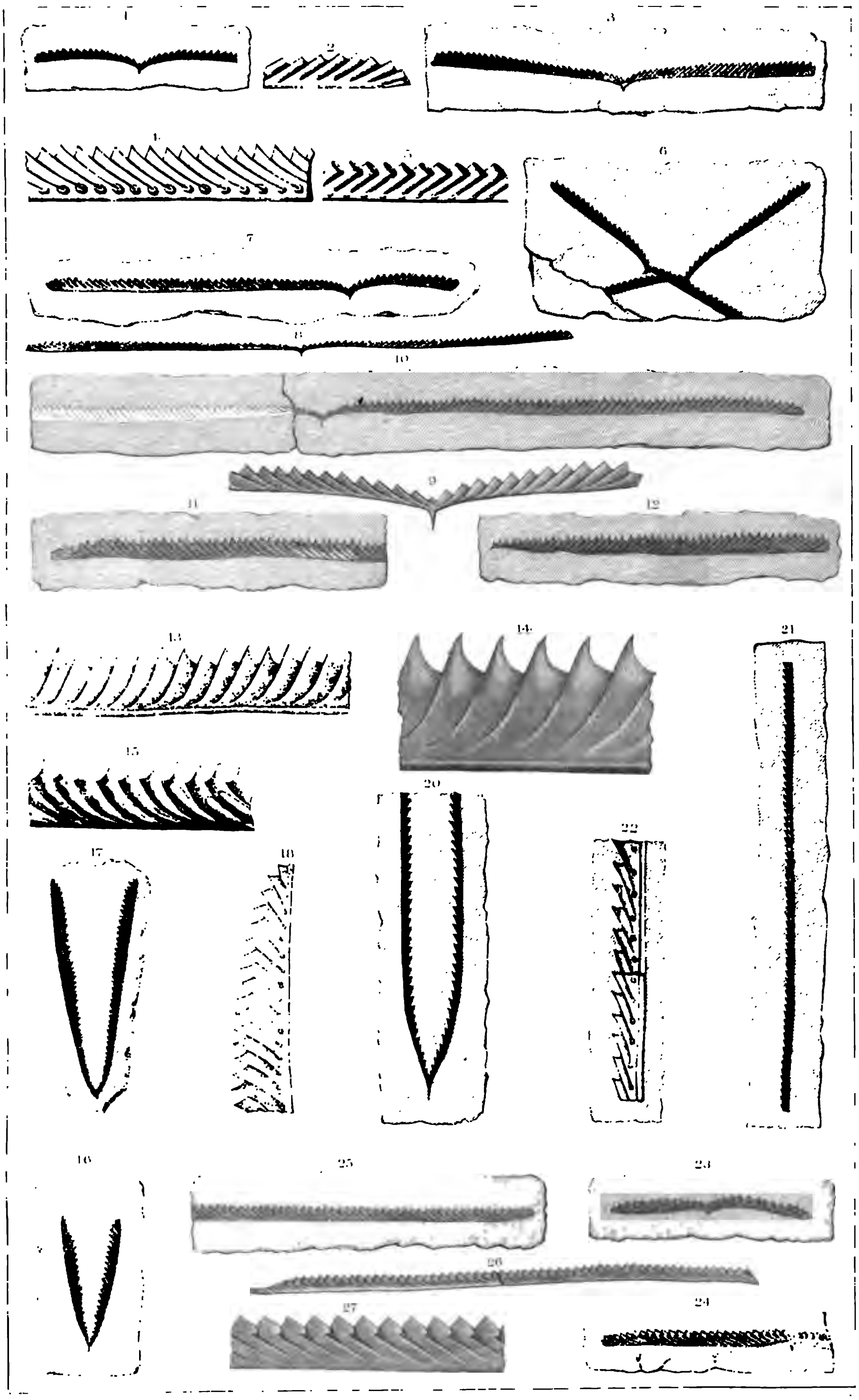

EXPLANATIONS OF PLATE II.

GRAPTOLITHUS SIMILIS, page 78.

Fig. 1. A very young individual of this species.
" 2. An individual somewhat more mature.
" 3. An enlargement showing the form of the radicle, and the cells near their origin, with a non-celluliferous space between.
" 4. A fragment of a longer stipe, which is imperfect at both extremities.
" 5. An enlargement of fig. 4.

GRAPTOLITHUS ARCUATUS, page 79.

Fig. 6. A stipe of a small individual, more than usually curved.
" 7. A stipe having a process just above and opposite the radicle.
" 8. A larger stipe, the cellules very clearly preserved.
" 9. A specimen showing the stipes on both sides of the radicle, and preserving their peculiar curvature very perfectly.
" 10. An enlargement of a portion from figure 8.

GRAPTOLITHUS EXTENSUS, page 80.

Fig. 11. A single stipe more than four inches long, with the radicle and base of the opposite stipe.
" 12. A fragment showing a part of the stipe on each side of the radicle, natural size.
" 13. The radicle and adjacent cellules, enlarged from fig. 12.
" 14. An enlargement of fig. 12 at a point about two inches from the radicle.
" 15. A fragment of a stipe where the cellules are distended by iron pyrites.
" 16. An enlargement from fig. 15.

GRAPTOLITHUS FLACCIDUS, page 143.

Fig. 17. A portion of a large fragment of slate, with parts of several individuals upon the surface; and showing the origin of eight individuals in the minute radicles. Some of these are indicated by asterisks on the engraving.
" 18. An enlargement to three diameters of the radicle and stipe-bases, with the cellules. From the point *a* on fig. 17.
" 19. A farther enlargement of a portion to show the form of the cellules, and the pustuliform appearances at the base of the divisions between them.

EXPLANATIONS OF PLATE II.

[illegible] [illegible], page 26.

Fig. 1. A very young individual of this species.
" 2. An individual somewhat more mature.
" 3. An enlargement showing the form of the radicle, and the cells near their origin, with a [illegible] space between.
" 4. A fragment of a longer stipe, which is imperfect at both extremities.
" 5. An enlargement of fig. 4.

[illegible] [illegible], page 28.

Fig. 6. A stipe of a small individual, more than usually curved.
" 7. A stipe having a process just above and opposite the radicle.
" 8. A larger stipe, the radicle very clearly preserved.
" 9. A specimen showing the stipes on both sides of the radicle, and preserving their proximal extremities very perfectly.
" 10. An enlargement of a portion from figure 8.

[illegible] [illegible], page 30.

Fig. 11. A single stipe more than four inches long, with the radicle and base of the opposite stipe.
" 12. A fragment showing a portion of the stipe on each side of the radicle, natural size.
" 13. The radicle and adjacent cellules, enlarged from fig. 12.
" 14. An enlargement of fig. 11 at a point about two inches from the radicle.
[illegible] the cellules are distended by iron pyrites.
[illegible]

[illegible] [illegible], page 143.

[illegible] a large fragment [illegible], with [illegible] of several individuals upon [illegible] showing the origin of eight individuals in the minute [illegible]. Some of these are indicated by asterisks on the engraving.
[illegible] the radicle and [illegible]-bases, with the [illegible] fig. [illegible].
[illegible] of a portion [illegible] show the form of the cellules, and the [illegible] appendages at the base of the divisions between them.

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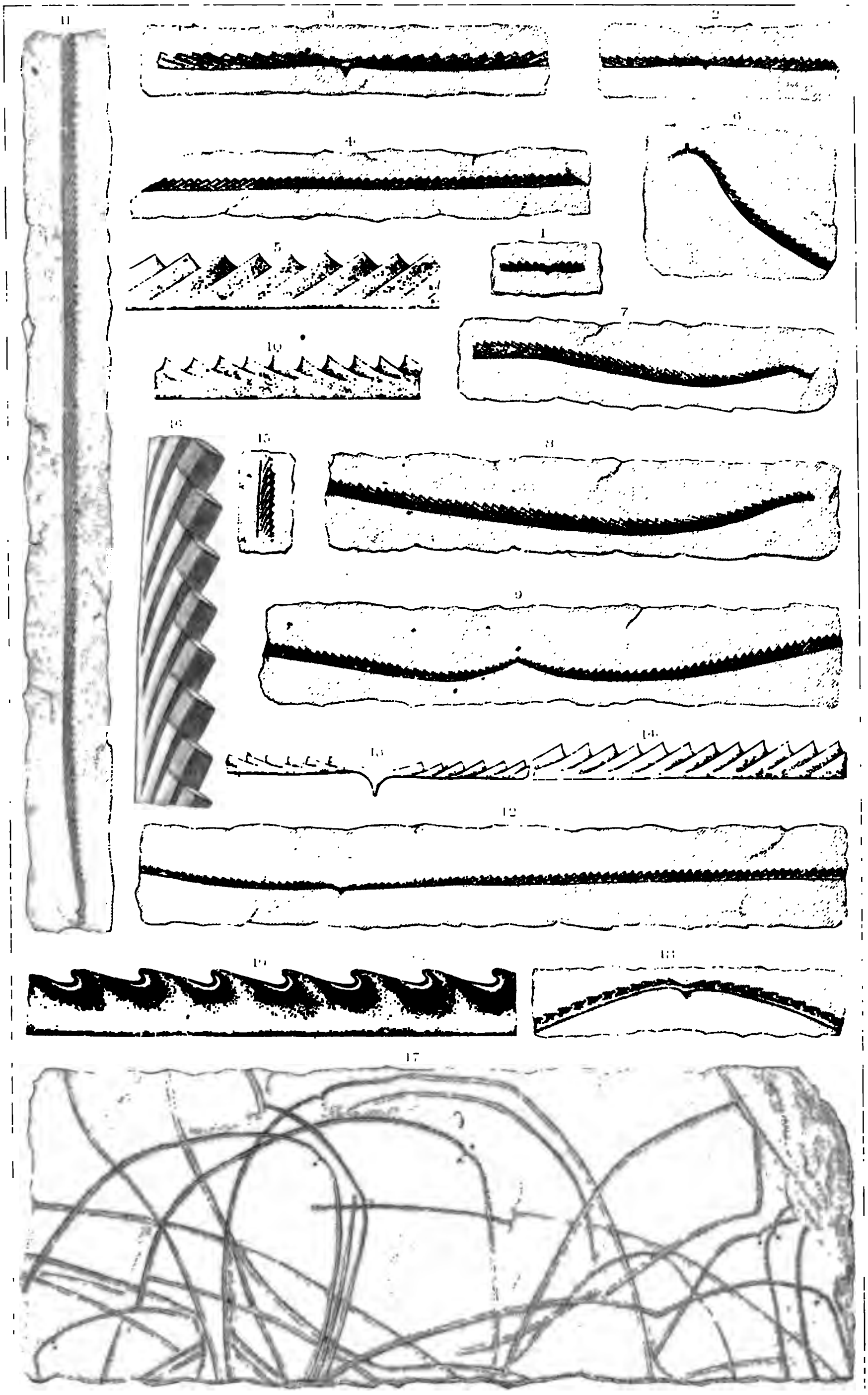

EXPLANATIONS OF PLATE III.

Graptolithus pennatulus, page 82.

Fig. 1. A young specimen with the minute radicle, the stipes diverging almost horizontally, or rectangularly to the radicle.
" 2. A young specimen with one stipe entire, and a part of the other, less diverging than fig. 1.
" 3. A single imperfect stipe of a young or half-grown individual, which is narrower than usual.
" 4. A larger stipe, which is entire from the base to the apex.
" 5. A large or full-grown single stipe, which is nearly entire.
" 6. An enlargement to three diameters from fig. 4, showing the form and proportion of the cellules, and cell-denticles.
" 7. An enlargement to the same degree as the preceding, from fig. 5.
" 8. A young specimen where the stipes are twisted near the base, giving an appearance as if the serrations were on the outer or lower side in relation to the direction of the radicle.

Graptolithus bifidus, page 73.

Fig. 9. An individual from the river St. Anne, showing a greater divergence of the stipes, which are wider than those from Point Lévis. (See plate i.)
" 10. An enlargement from one of the stipes of the preceding, showing the form of serratures, and the minute pustules at the base of the cell-divisions.

Graptolithus bryonoides, page 84.

Fig. 11. A fragment of a stipe from the rough shales containing *Phyllograptus ilicifolius*. In the character of the cell-denticles it resembles the specimen pl. iv, fig. 9 and with that one may constitute a distinct species.
" 12. An enlargement of a part of the specimen fig. 11.

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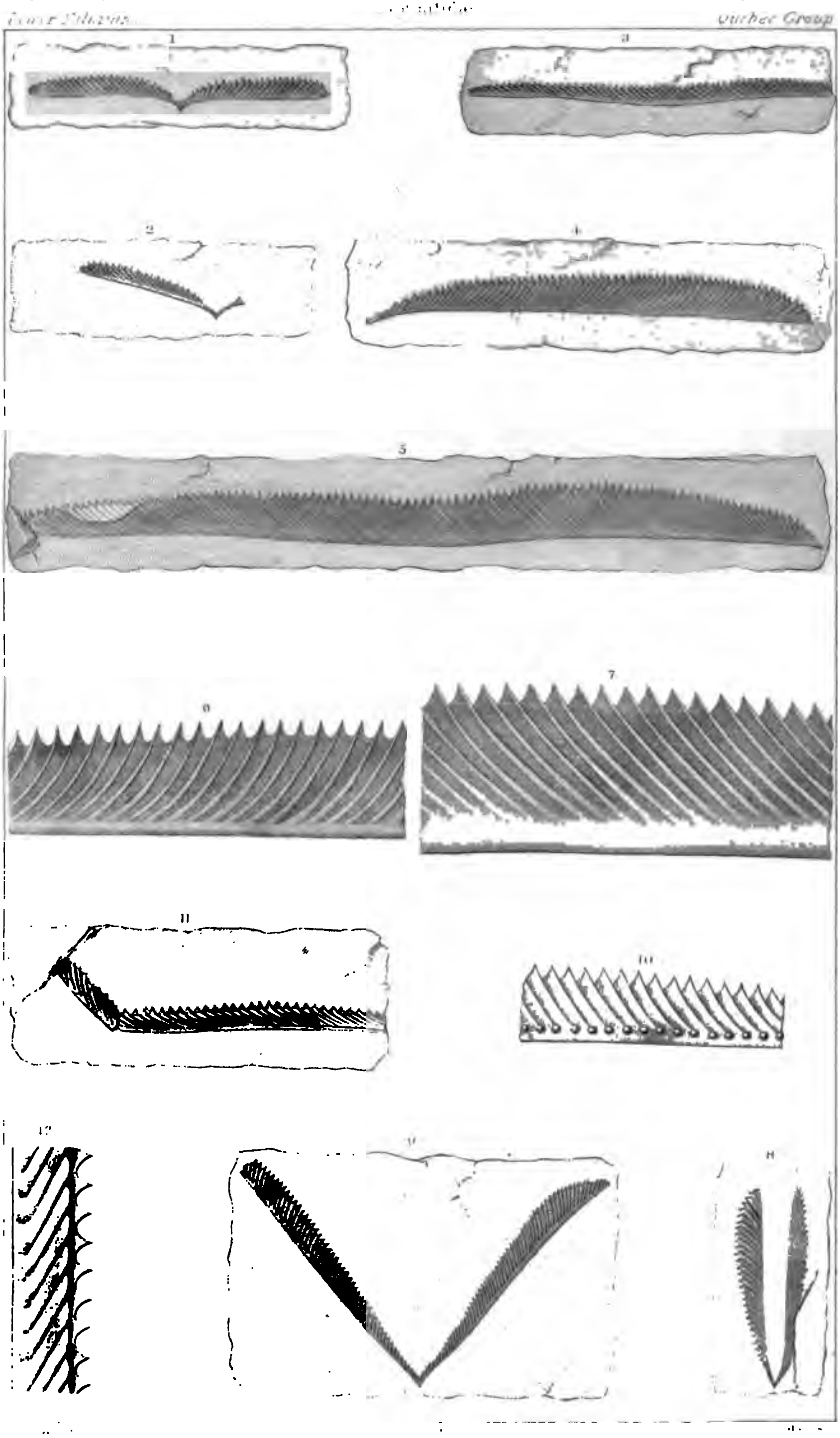
Lower Silurian [illegible] Plate 3

[illegible] Quebec Group



EXPLANATIONS OF PLATE IV.

GRAPTOLITHUS BRYONOIDES, page 84.

Figs. 1, 2, 3. Young individuals of this species.
" 4. An older individual.
" 5. A young specimen preserving two of the stipes, the funicle having been broken.
" 6. An enlargement from fig. 1, showing the radicle, funicle, and origin of the four stipes, with a few of the earlier cellules.
" 7. An older and larger specimen.
" 8. An enlargement from fig. 7 showing the character and proportions of the cellules.
" 9. A small individual, preserving the four stipes in part, which are somewhat more slender than the usual forms of this species.
" 10. An enlargement of the base of the specimen, showing the cell-denticles on one of the stipes, and a proportionally longer funicle than in fig. 8.
" 11. An extremely elongated stipe, the lower end showing the commencement of growth; the distal extremity is broken.

⁂ Figs. 9 and 10 may possibly prove to be distinct species. (See pl. iii, figs. 11, 12.)

GRAPTOLITHUS DENTICULATUS, page 88.

Fig. 12. A small imperfect specimen, preserving three of the stipes.
" 13. A larger and more nearly entire specimen, showing the four stipes. Their junction at the base is not quite satisfactorily shown.
" 14. A part of a single stipe, in which the cellules are well shown on one part; while they are compressed and nearly obliterated on the left of the curve.
" 15. An impression of a part of a stipe which is nearly straight; the imprint of the axis or thickened margin is not defined.
" 16. An enlargement from figure 14, showing the form of the cell-denticles, and the strong marginal axes; one portion represented with the substance remaining, and the other as an imprint.

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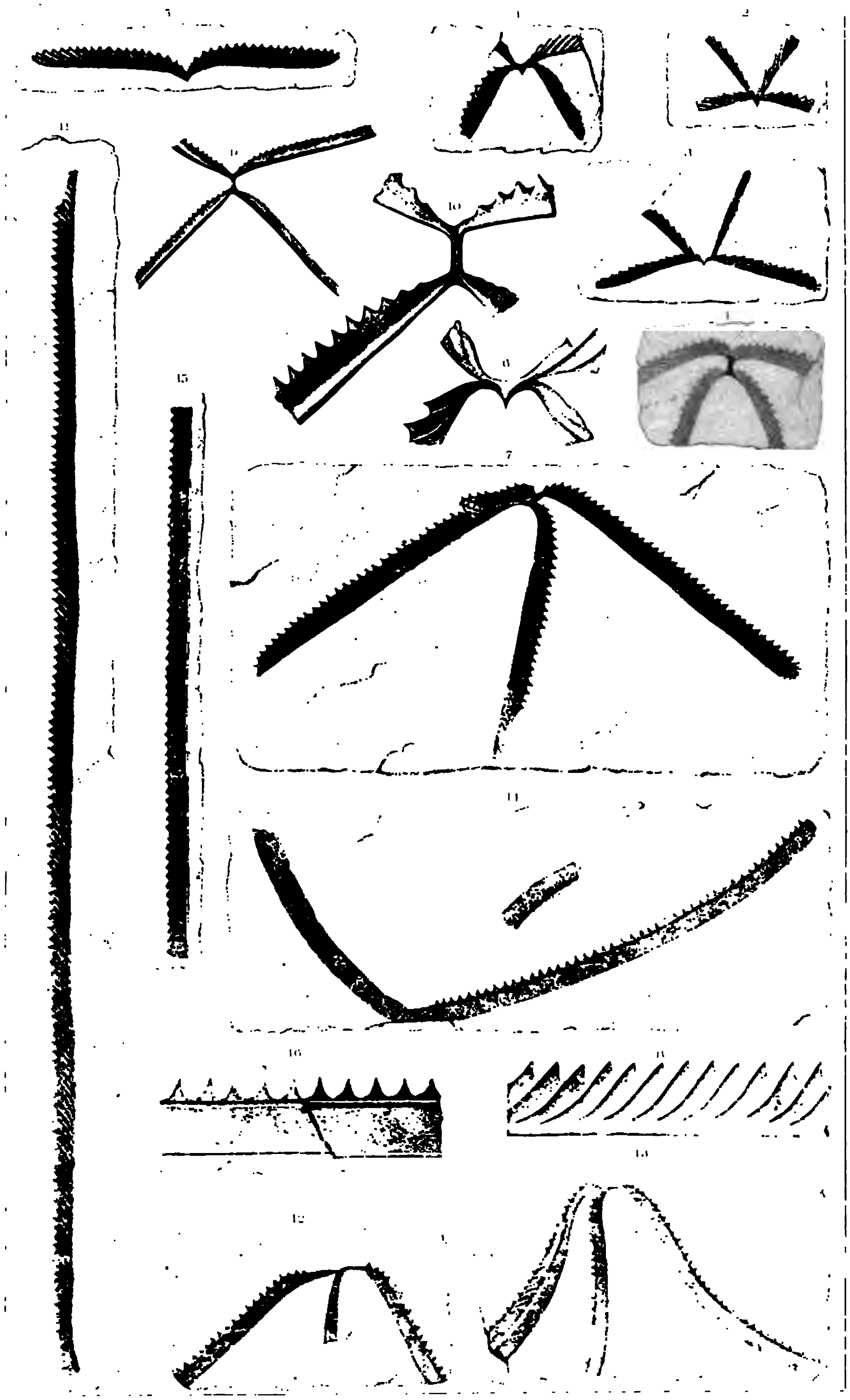

EXPLANATIONS OF PLATE V.

Graptolithus quadribrachiatus, page 91.

Fig. 1. A large specimen with stipes vertically compressed.
" 2. A young specimen in which one of the stipes appears to be subdivided.
" 3. An individual with stipes a little curved, the back of the stipe visible, and showing no serratures.
" 4. A frond with one of the stipes broken off; one showing the cellules and distinct striæ parallel to the cell-partitions, while the other two are turned so as to obscure the cellules.
" 5. An enlargement from fig. 1 : the stipe has been vertically compressed, causing the cellules to show a less angle with the stipe than in the normal condition.

Graptolithus fruticosus, page 90.

Fig. 6. A small individual with the extremities of the radicle and stipes broken off.
" 7. An enlargement from fig. 6. The serratures are either imperfect or shrunken, and do not present the characters seen in better-preserved specimens.
" 8. An individual nearly entire, with an extremely long and slender radicle, but imperfectly preserved in the outline of its parts.

Graptolithus pennatulus, page 82.

Fig. 9. A single stipe of this species ? The specimen is a large stipe, somewhat obscurely preserved upon the surface of a slab of slate, with *G. extensus*, *G. bryonoides*, and *Phyllograptus ilicifolius*. It is from the same locality with *G. bifidus* at Point Lévis. In the form of the stipe, and its gradual diminution towards the distal extremity, as well as in the absence of visible pustules at the base of the cellules, it has the habit of *G. pennatulus*. Being the only individual observed from this locality, and the resemblance to *G. bifidus* being very close, I have referred it with much hesitation to *G. pennatulus*.

Graptolithus crucifer, page 92.

Fig. 10. View of the specimen from which the description is drawn.
" 13. The disc of a young individual probably of this species.

Graptolithus Headi (?) page 94.

Figs. 11 and 12. The central discs of two individuals which may belong to *G. Headi*.

EXPLANATIONS OF PLATE V.

[illegible] page 14.

Fig. 1. [illegible] vertically compressed.

" 2. [illegible] appears to be subdivided.

" 3. [illegible] and [illegible]

" 4. [illegible]

" 5. [illegible]

[illegible] page 16.

Fig. [illegible]

" [illegible]

" [illegible]

[illegible] page 22.

Fig. 8. [illegible]

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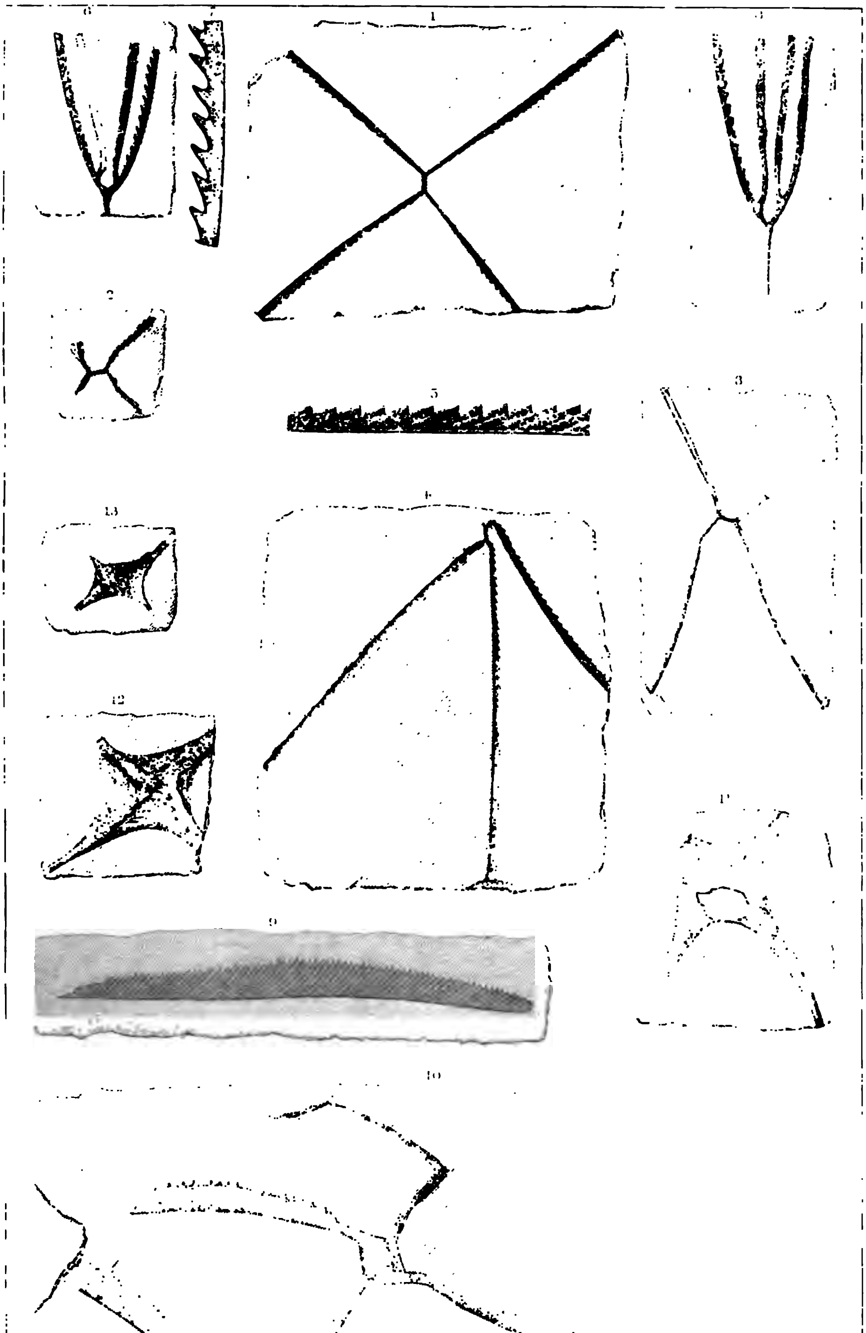

EXPLANATIONS OF PLATE VI.

GRAPTOLITHUS FRUTICOSUS, page 90.

Fig. 1. A fragment showing two of the stipes entire, and the bases of two others; the radicle extending to the margin of the specimen.

" 2. A specimen preserving three of the stipes, one of them entire, and showing some irregularities in the bifurcation where the one is broken off.

" 3. An enlargement of the right-hand stipe of the specimen fig. 1.

GRAPTOLITHUS BRYONOIDES, page 84.

Fig. 4. A frond in which three of the stipes, and the base of the fourth, are preserved. The specimen shows some peculiarity in the union of the parts by the slender funicle. From the river Ste. Anne.

GRAPTOLITHUS QUADRIBRACHIATUS, page 91.

Fig. 5. A frond preserving one stipe partially entire, and others broken off: the funicle and radicle-point are well preserved.

" 6. An enlargement from the specimen fig. 5, showing the form and proportions of cellules in their more perfect preservation, with the striæ parallel to the cell-margins well preserved.

GRAPTOLITHUS CRUCIFER? page 92.

Fig. 7. A central disc of *G. crucifer*, with the bases of the branches.

GRAPTOLITHUS HEADI, page 94.

Fig. 8. A representation of the specimen of the natural size, and as it occurs on the surface of the stone. (The upper separated portion of the stipe is placed a little lower in the figure than it is on the stone, in order to bring it within the dimensions of the plate.)

GRAPTOLITHUS ALATUS, page 93.

Fig. 9. The specimen represented as it occurs on a fragment of slate. The back of the stipes shows faint indentations, but they are made too strong in the engraving.

EXPLANATIONS OF PLATE VI.

[illegible] [illegible], page 90.

Fig. 1. A fragment showing two of the stipes entire, and the bases of two others; the [illegible] [illegible] on the margin of the specimen.

" 2. A specimen preserving three of the stipes, one of them entire, and showing some irregularities in the bifurcation where the one is broken off.

" 3. An enlargement of the right-hand stipe of the specimen fig. 1.

[illegible] [illegible], page 84.

Fig. 4. A frond in which three of the stipes, and the base of the fourth, are preserved. The specimen shows some peculiarity in the union of the parts by the slender funicle. From the river Ste. Anne.

[illegible] [illegible], page 91.

Fig. 5. A frond preserving one stipe partially entire, and others broken off: the funicle and radicle-point are well preserved.

" 6. An enlargement from the specimen fig. 5, showing the form and proportions of cellules in their more perfect preservation, with the striæ parallel to the cell-margins well preserved.

GRAPTOLITHUS CRUCIFER? page 97.

Fig. [illegible] A [illegible] of *G. c*[illegible] [illegible]s.

Gr[illegible]

Fig. [illegible] [illegible] [illegible] of the spec[illegible] [illegible] as it occurs [illegible] [illegible] stone. (The [illegible] [illegible] is [illegible]d [illegible] in the figure [illegible] [illegible] in order to bring it [illegible] dimensions of the plate.)

G[illegible] ALATUS, page [illegible]

Fig. [illegible] [illegible] as it occurs [illegible] [illegible] of stone. The [illegible] [illegible] [illegible] indentations, but they are made too strong in the engraving.

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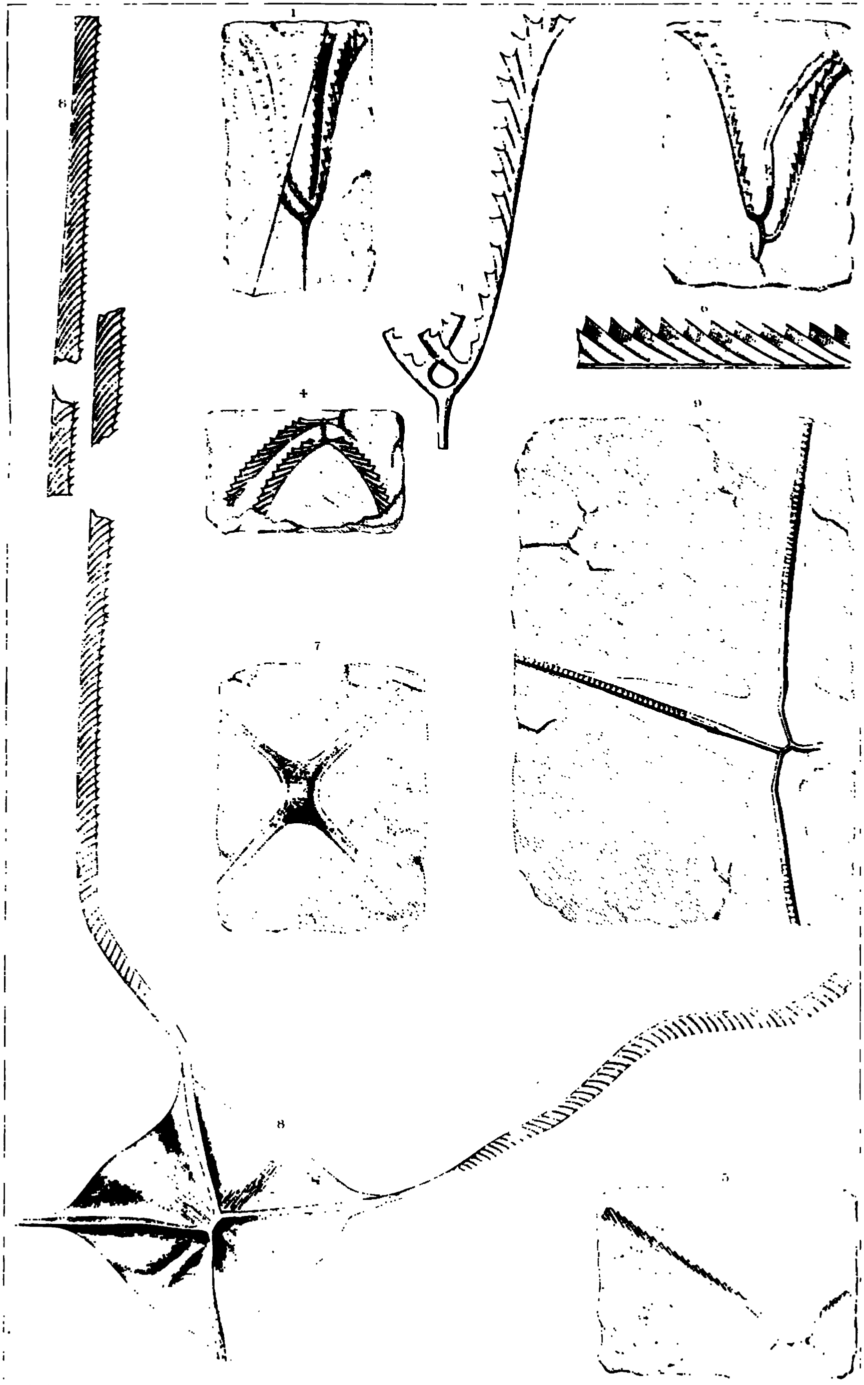
Graptolitidæ



R. P. Whitfield, [illegible] James Hall Dir. [illegible]

EXPLANATIONS OF PLATE VII.

GRAPTOLITHUS OCTOBRACHIATUS, page 96.

Fig. 1. A large individual preserving two of the stipes to the length of eight inches, and another to nearly the same extent, while the rest are broken off at less distances from the disc. The flexibility of their substance is well shown in the recurved stipe at the left-hand side of the figures. Although this specimen preserves the most extended stipes of any in the collection, the disc is smaller than in several of the other specimens.

" 2. The exterior of a large disc of this species, with the stipes broken off a little beyond its margin. The two longer portions are so turned as to show the cellules.

" 3. A portion of a large disc, showing the exterior or non-celluliferous face of the frond, and preserving portions of four of the stipes.

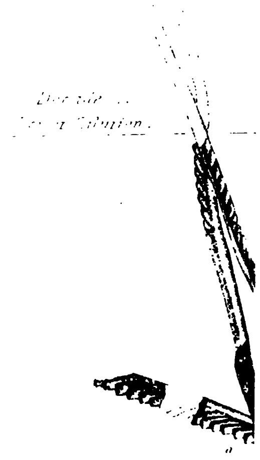
" 4. A frond with the stipes broken off at different distances from the centre. The substance of the disc or cup is imperfect,—a condition which apparently existed while the body was in a living state.

" 5. An enlargement from one of the stipes of fig. 1, at *c*, looking upon the apertures of the cellules, which are somewhat compressed.

" 6. An enlargement from the same at *b*, where the substance is laterally compressed.

" 7. An enlargement from the same, where the substance is obliquely compressed at *a*.

Figs. 5 and 7 are taken from casts made in the impressions left by removal of the substance of the graptolite.



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EXPLANATIONS OF PLATE VIII.

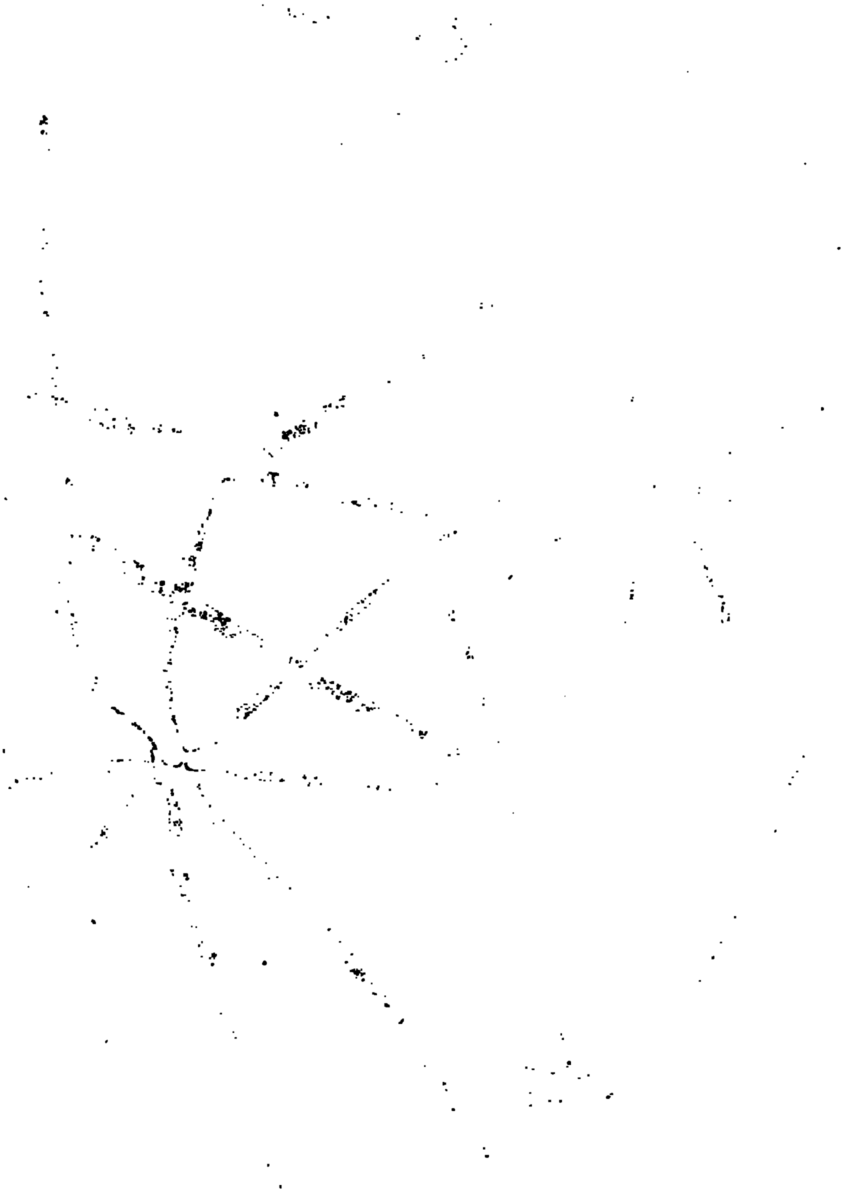
GRAPTOLITHUS OCTOBRACHIATUS, page 96.

Fig. 1. A symmetrical frond preserving parts of all the stipes, two of them apparently almost entire; several of them had been abruptly bent before being imbedded in the stone.

2. A frond preserving eight stipes, but without a disc. The specimen does not afford any evidence that a disc has ever existed.

" 3. A frond with small disc and somewhat slender stipes. One side preserves the usual character of four stipes, while the other has but three.

" 4. A frond which is abnormally developed; one side exhibiting the four stipes with the disc, while on the other side the funicle is apparently extended in a single stipe only.



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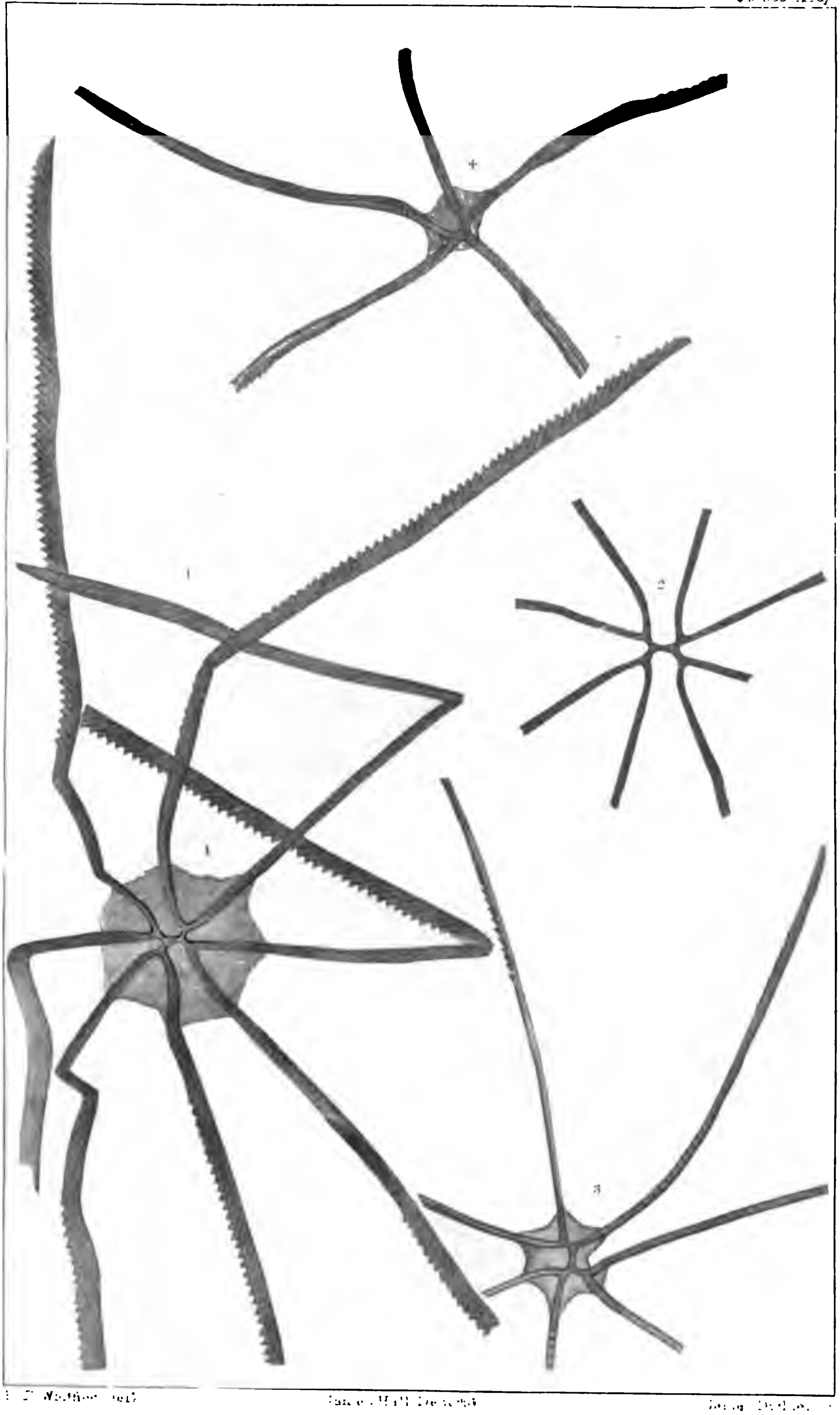
Decade 2.
Lower Silurian

Graptolitidae.

Plate 8.
Quebec Group



[illegible] Matthew del. [illegible] [illegible]

EXPLANATIONS OF PLATE IX.

GRAPTOLITHUS LOGANI, page 100.

Fig. 1. A specimen of slate, preserving portions of three individuals (two only given in the illustration). The disc had probably been removed by maceration before they were imbedded, but the stipes are preserved to a length of more than seven inches. It does not appear that this exhibits the entire skeleton : the stipes were originally longer. The serrated margins are not always shown at equal distances from the centre ; but this is due to accidental position, some stipes showing the exterior surface for some distance, and then gradually turning and becoming flattened laterally.

" 2. A specimen showing the disc almost entire.

" 3. An individual showing the exterior surface the central portions entire, with the impression of the connecting disc, some portions of which remain attached to the stipes. The extent and outline of the disc are distinctly seen. The appearance of serratures is due to exfoliation, which shows the impression of the celluliferous side of the stipe upon the stone.

" 4. A specimen exhibiting the half of an individual, with the disc unequally extended between the rays. The margins are all apparently entire, and this inequality, to whatever accident due, existed in the living animal.

" 5. Exterior view of an individual showing some remaining portions of the disc ; the stipes are all broken off beyond the bifurcations.

" 6. Another individual showing the inner side, with the commencement of the cells, which appear in some places in double series. The substance of the disc is removed.

" 7. Enlargement of the exterior surface of the central portion of the specimen fig. 5.

" 8. Enlargement of the inner surface of the specimen fig. 6, giving the appearance of a double series of cells separated by a depressed line in the substance of the stipe. Sometimes this separation appears to be actual, while elsewhere the apparent division is due to the depression along the centre.

" 9. Enlargement of a fragment of a stipe, showing the form and proportions of the cellules.

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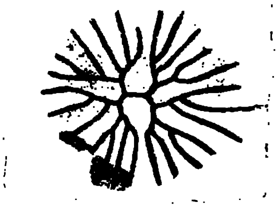

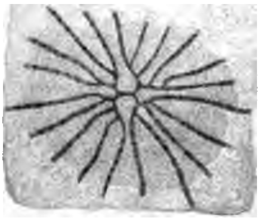

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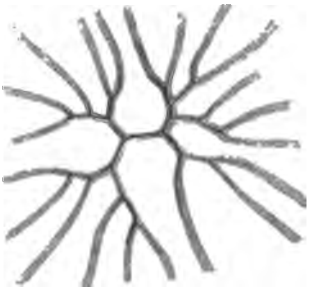

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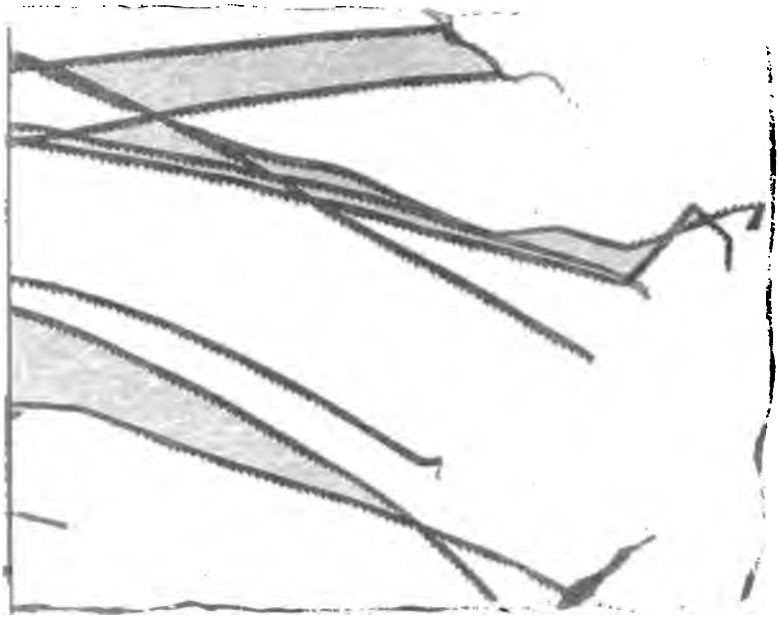

EXPLANATIONS OF PLATE X.

GRAPTOLITHUS OCTONARIUS, page 95.

Fig. 1. A specimen of natural size, much broken and distorted from pressure.
" 2. An enlargement from the preceding figure.

GRAPTOLITHUS FLEXILIS, page 103.

Fig. 3. A fragment of slate preserving more than half of a frond, and showing the folding and crossing of some of the branches.
" 4. A fragment preserving parts of three individuals, the extremities of the branches all broken off.
" 5. The central portion of the frond of another individual.
" 6. Separated branches preserving the cellules in unusual perfection.
" 7. An enlargement of the centre of the frond, fig. 5, showing the short radicle and the usual mode of branching. The central part of the axis is rounded, with a narrow corneous alation at the sides.
" 8. A bifurcated fragment enlarged, from fig. 4: the cellules have been flattened vertically, causing them to be visible in slight indentations on both sides of the axis.
9. A portion of a branchlet enlarged from fig. 6, showing one part compressed laterally, with the cellules fully expanded, while the other, on the right hand, is gradually twisted so as to show only the back of the branchlet.

EXPLANATION OF PLATE VIII.

GRAPTOLITHUS OCTOBRACHIATUS, page [illegible].

Fig. 1. A quadrangular frond preserving parts of all the stipes, two of them apparently almost entire; several of them had been abruptly bent before being imbedded in the stone.

2. A frond preserving eight stipes, but without a disc. The specimen does not afford any evidence that a disc has ever existed.

3. A young frond with small disc and somewhat slender stipes. One side preserves the usual character of four stipes, while the other has but three.

4. A frond which is abnormally developed; one side exhibiting the four stipes with the disc, while on the other side the frond is apparently extended in a single [illegible]

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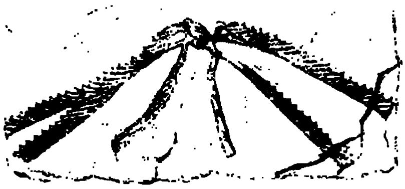

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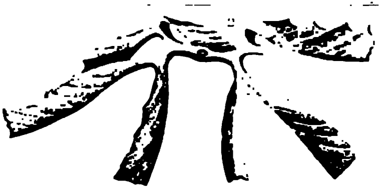

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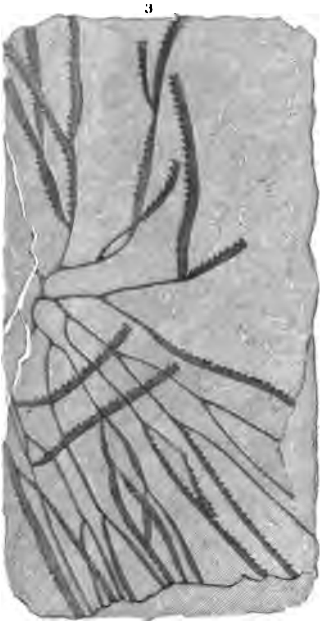

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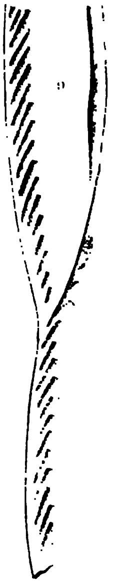

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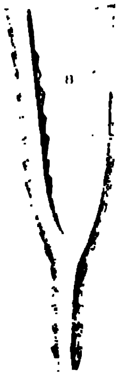

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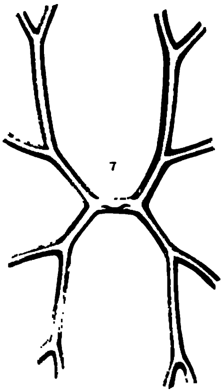

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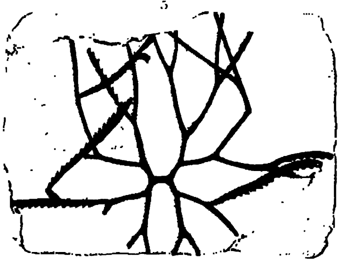

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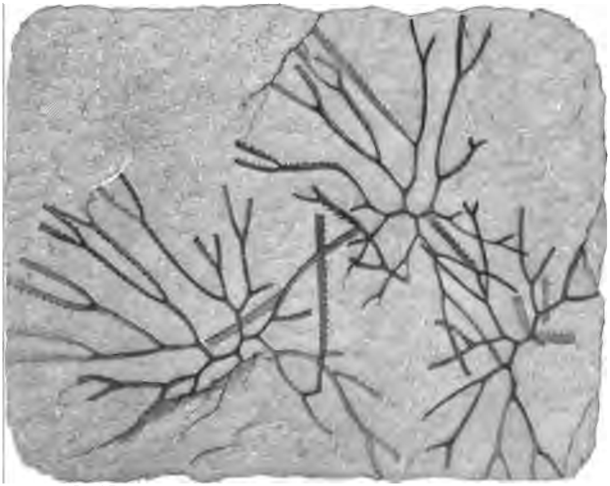

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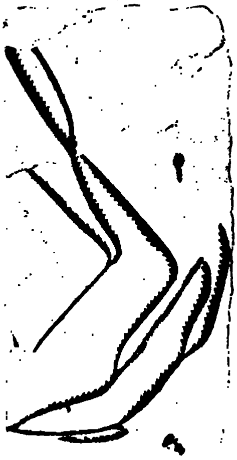

EXPLANATIONS OF PLATE XI.

GRAPTOLITHUS RIGIDUS, page 105.

Fig. 1. A fragment preserving the centre and principal branches.
" 2. A larger specimen, showing the principal ramifications of the branches. This and the preceding specimen show only what appears to be the non-celluliferous portion of the frond.
" 3. The extreme parts of some branchlets laterally compressed, showing the celluliferous parts of the frond.
" 4. An enlargement of one of the branchlets of fig. 3.
" 5. A strong branch with part of the branchlets, showing the lower side or non-celluliferous portion of the frond.

GRAPTOLITHUS ABNORMIS, page 106.

Fig. 6. A fragment of slate preserving the centre and the branches on one side to beyond the first bifurcation. The other side is imperfect, and apparently less developed.

GRAPTOLITHUS LOGANI, page 100.

Fig. 7. The central part of an individual without disc, showing five stipes on one side and four on the other. This is supposed to be an abnormal form of *G. Logani.*

EXPLANATIONS OF PLATE IX.

GRAPTOLITHUS LOGANI, page [illegible].

Fig. 1. A specimen of slate preserving portions of three individuals (two only given in the illustration). The disc had probably been removed by maceration before they were imbedded, but the stipes are preserved to a length of more than seven inches. It does not appear that this exhibits the entire character; the stipes were originally longer. The serrated margins are not always shown at equal distances from the median; but this is due to accidental position, some stipes showing the exterior surface for some distance, and then gradually turning and becoming flattened laterally.

" 2. A specimen showing the disc almost entire.

" 3. An individual showing the exterior surface: the central portions entire, with the impressions of the connecting disc, some portions of which remain attached to the stipes. The centre and outline of the disc are distinctly seen. The appearance of serrations is due to exfoliation, which shows the impression of the celluliferous side of the stipes upon the stone.

" 4. A specimen exhibiting the half of an individual, with the disc unequally extended between the stipes. The margins are all apparently entire, and this inequality, by whatever accident due, existed in the living animal.

" 5. Lateral view of an individual showing some remaining portions of the disc; the [illegible] arrangement of the cells, [illegible] The substance of the disc [illegible] specimen fig. 5. [illegible] appearance [illegible] of [illegible] else- [illegible] structure. [illegible] proportions of

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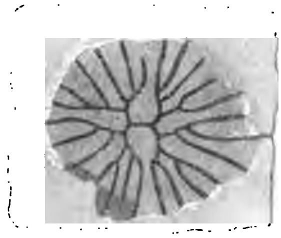

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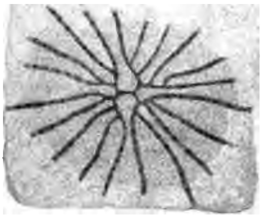

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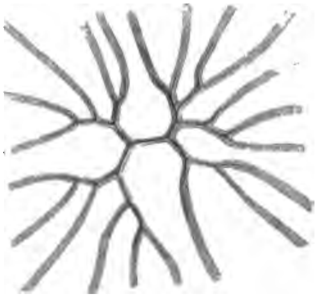

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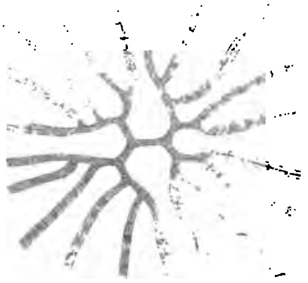

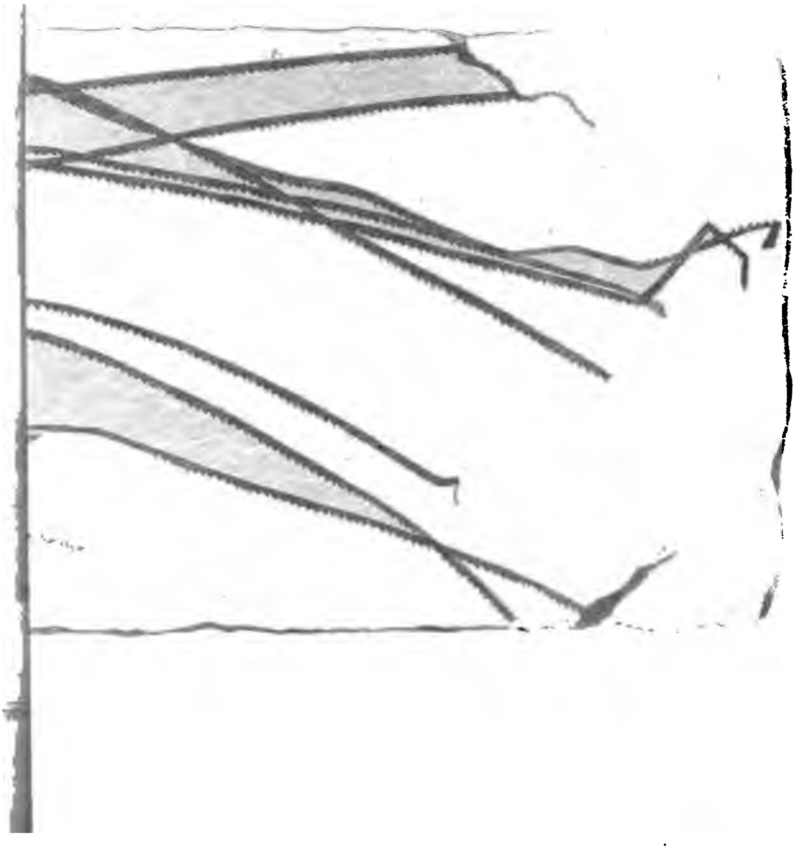

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EXPLANATIONS OF PLATE X.

GRAPTOLITHUS OCTONARIUS, page 95.

Fig. 1. A specimen of natural size, much broken and distorted from pressure.
" 2. An enlargement from the preceding figure.

GRAPTOLITHUS FLEXILIS, page 103.

Fig. 3. A fragment of slate preserving more than half of a frond, and showing the folding and crossing of some of the branches.
" 4. A fragment preserving parts of three individuals, the extremities of the branches all broken off.
" 5. The central portion of the frond of another individual.
" 6. Separated branches preserving the cellules in unusual perfection.
" 7. An enlargement of the centre of the frond, fig. 5, showing the short radicle and the usual mode of branching. The central part of the axis is rounded, with a narrow corneous alation at the sides.
" 8. A bifurcated fragment enlarged, from fig. 4: the cellules have been flattened vertically, causing them to be visible in slight indentations on both sides of the axis.
9. A portion of a branchlet enlarged from fig. 6, showing one part compressed laterally, with the cellules fully expanded, while the other, on the right hand, is gradually twisted so as to show only the back of the branchlet.

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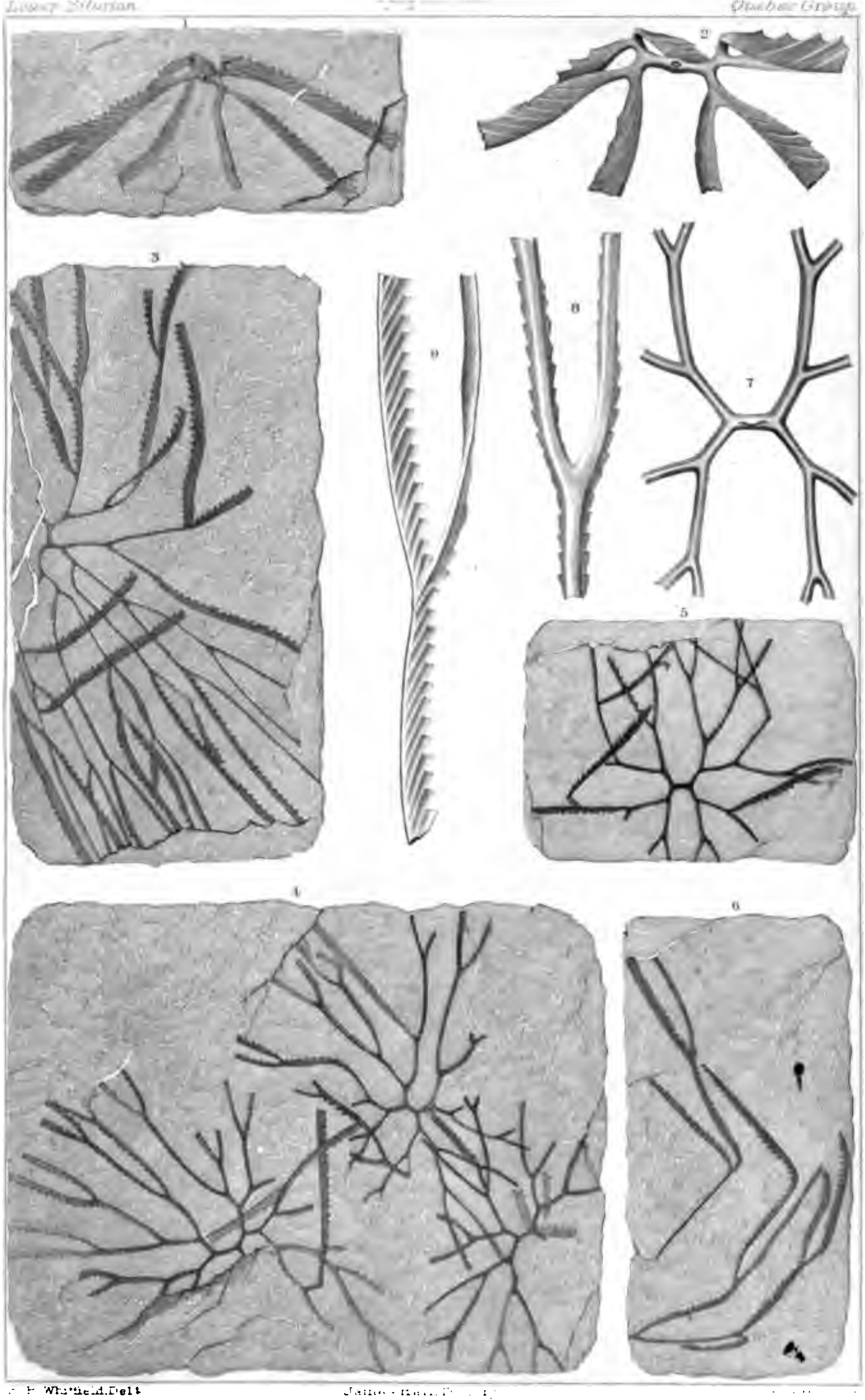
Decade 2. Plate 16.

Graptolitidæ.

Lower Silurian. Quebec Group.



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EXPLANATIONS OF PLATE XI.

GRAPTOLITHUS RIGIDUS, page 105.

Fig. 1. A fragment preserving the centre and principal branches.

" 2. A larger specimen, showing the principal ramifications of the branches. This and the preceding specimen show only what appears to be the non-celluliferous portion of the frond.

" 3. The extreme parts of some branchlets laterally compressed, showing the celluliferous parts of the frond.

" 4. An enlargement of one of the branchlets of fig. 3.

" 5. A strong branch with part of the branchlets, showing the lower side or non-celluliferous portion of the frond.

GRAPTOLITHUS ABNORMIS, page 106.

Fig. 6. A fragment of slate preserving the centre and the branches on one side to beyond the first bifurcation. The other side is imperfect, and apparently less developed.

GRAPTOLITHUS LOGANI, page 100.

Fig. 7. The central part of an individual without disc, showing five stipes on one side and four on the other. This is supposed to be an abnormal form of *G. Logani.*

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Decade II.   Plate [illegible]

Lower Silurian.   Quebec group.

Graptolitidae.

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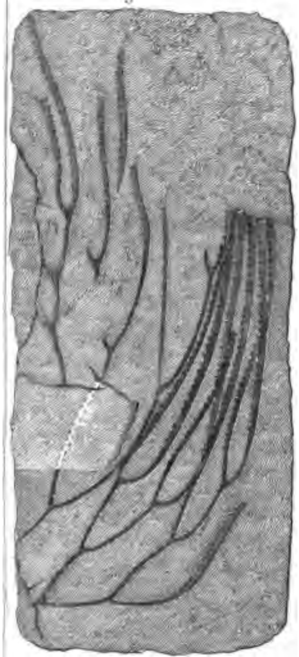

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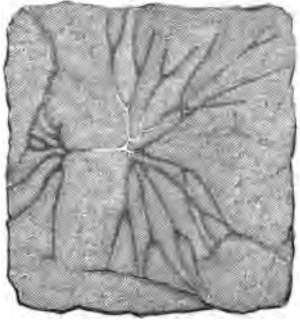

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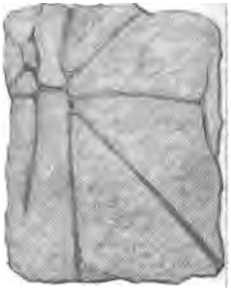

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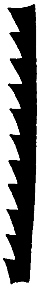

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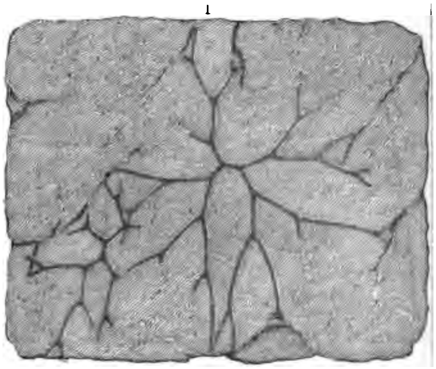

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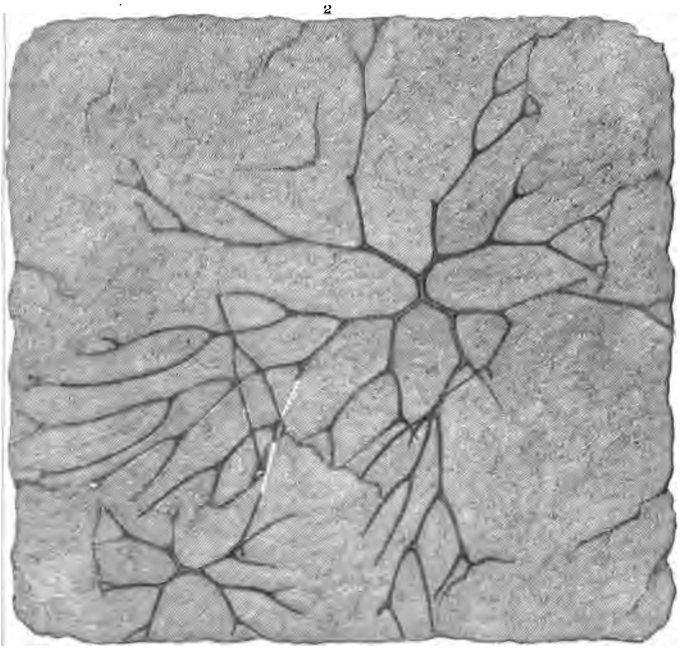

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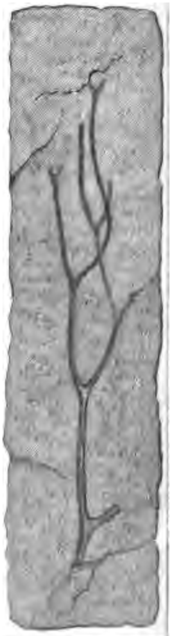

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EXPLANATIONS OF PLATE XII.

Graptolithus Richardsoni, page 107.

Fig. 1. A fragment of slate, preserving a stipe, with six branches in its apparent continuation, and impressions of two others in the intermediate space; two of these again bifurcating.

" 2. A fragment preserving several branchlets, which are compressed in different directions, showing the sides and apertures of the cellules.

" 3. An impression of a bifurcating fragment, the cellules of which were filled with mineral matter and vertically compressed.

" 4. A fragment of a branch laterally compressed.

" 5. The impression of a bifurcating branch where the cellules are somewhat obliquely compressed, and partially filled with mineral matter.

" 6. A fragment enlarged, giving a lateral view of the cellules.

" 7. An enlargement from an impression of a branchlet, from fig. 5, which is obliquely compressed, having the cellules filled with mineral matter.

" 8. Enlargement of a fragment, from fig. 1, where the cellules are filled with mineral matter and vertically compressed.

Graptolithus ramulus, page 108.

Fig. 9. A small bifurcating branch.

" 10. An enlargement of fig. 9, showing the form and extent of the cellules.

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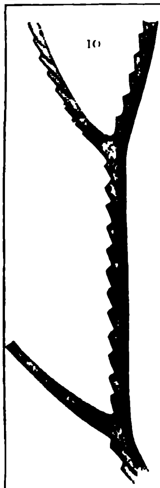

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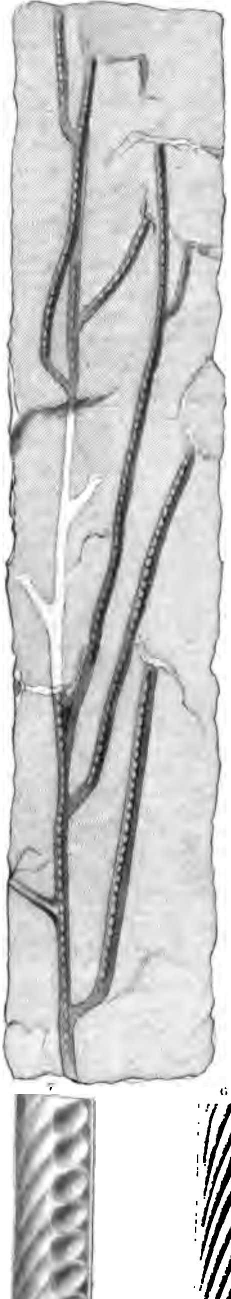

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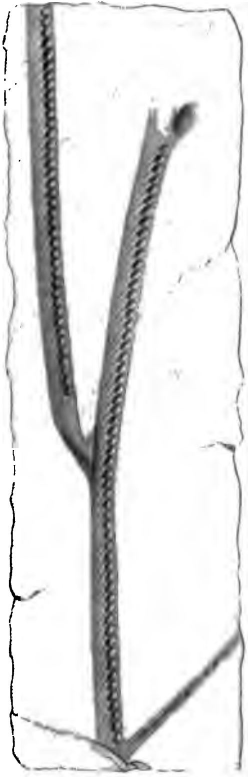

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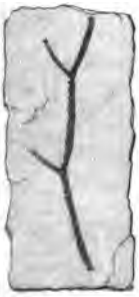

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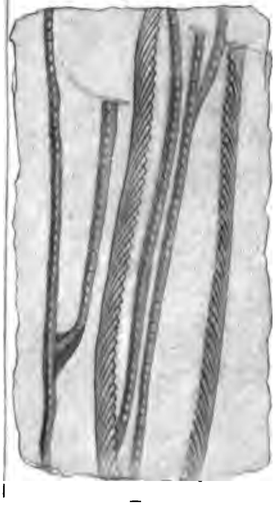

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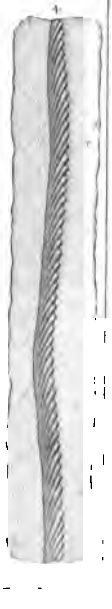

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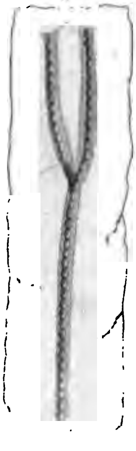

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EXPLANATIONS OF PLATE XIII.

GRAPTOLITHUS QUADRIMUCRONATUS, page 144.

Fig. 1. Part of a stipe compressed in a slightly oblique direction, still showing the cellules on the two sides.

" 2. A stipe compressed more obliquely, so as nearly to obscure the cellules on one side.

" 3. A specimen compressed vertically to the celluliferous side of the stipe.

" 4, 5, and 6. Enlargements from specimens, figs. 1, 2, and 3 respectively.

" 7. Enlargement from a specimen where the solid axis lies near to one side.

" 8. A specimen obliquely compressed, so that the mucronate points at one angle of the cellules of the left side, are pressed through the test, and show on the surface as a range of pustules. The axis is displaced, and seen on one side of the centre.

" 9. A diagram representing a theoretical longitudinal section.

" 10. A transverse section of a stipe with the mucronate extensions of the cell-margins.

CLIMACOGRAPTUS ANTENNARIUS, page 112.

Fig. 11. A young individual, compressed in such a manner that the cell-apertures are not shown upon the margin.

" 12. A flattened stipe, presenting only the mucronate terminations of the cell-apertures beyond the margin.

" 13. An older individual, showing the margins of the stipe extending beyond the cell-apertures, while the cellules are visible in the substance of the stipes as darker areas.

DIPLOGRAPTUS INUTILIS, page 111.

Fig. 14. A piece of slate preserving fragments of two individuals.

DIPLOGRAPTUS PRISTINIFORMIS, page 110.

Fig. 15. A fragment of a stipe, showing the usual form and proportions of the best-preserved specimens.

" 16. A smaller individual, with the mid-rib or axis extending beyond the body of the stipe.

" 17. An enlargement from fig. 16, showing more distinctly the form of the cellules.

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Decade 2 — Plate 13.

Graptolitidae

Lower Silurian — Quebec Group.

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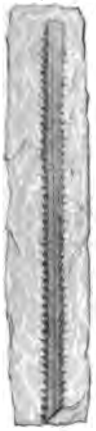

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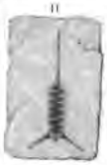

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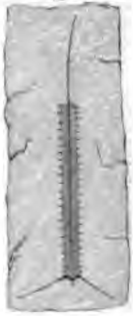

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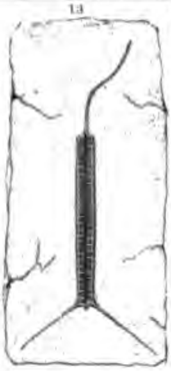

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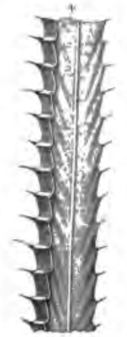

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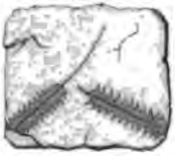

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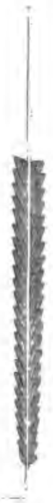

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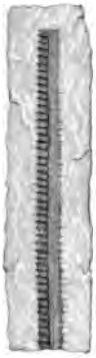

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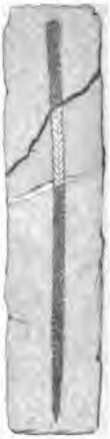

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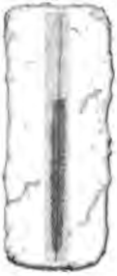

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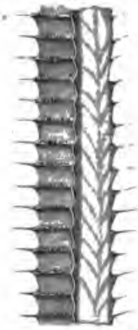

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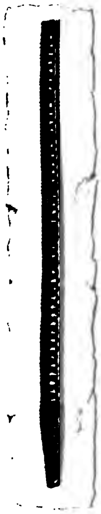

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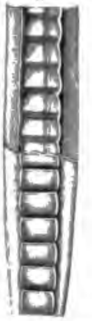

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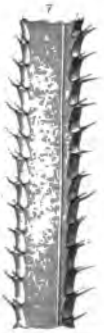

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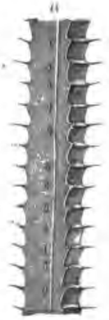

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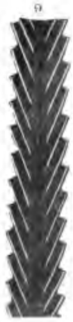

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EXPLANATIONS OF PLATE XIV.

RETIOLITES ENSIFORMIS, page 114.

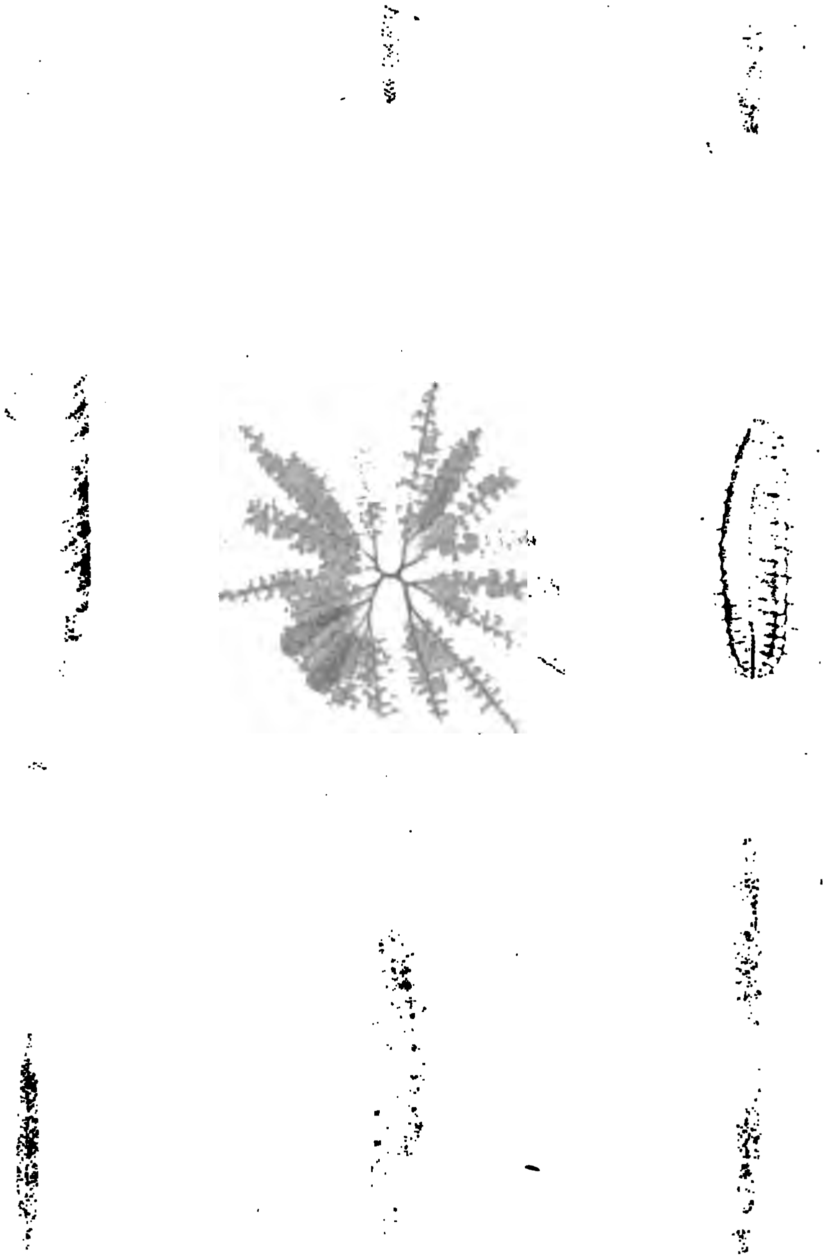
Figs. 1, 2, 3. Individuals showing gradations in growth, and slight differences in their proportions.
" 4. A nearly entire stipe of the largest size observed.
" 5. An enlargement from the specimen fig. 2.

RETIOGRAPTUS TENTACULATUS, page 116.

Fig. 6. An individual of the natural size, with the marginal reticulations nearly entire.
" 7. The preceding specimen enlarged.
" 8. An enlargement of another individual, where the marginal reticulations are but partially preserved.

RETIOGRAPTUS EUCHARIS, page 146.

Fig. 9. An illustration of a compound form of the genus, enlarged to four diameters.



EXPLANATIONS OF PLATE XIV.

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RETIOGRAPTUS TENTACULATUS, page 116.

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" 7. The preceding specimen enlarged.
" 8. An enlargement of another individual, where the marginal reticulations are but partially preserved.

RETIOGRAPTUS EUGENIAE, page 116.

Fig. 9. A [illegible] of a compound form of the genus, enlarged to four diameters.

Geological Survey of Canada.

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Graptolitidæ.

Plate 2. [illegible]

Plate 14. Quebec Group.

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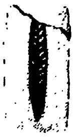

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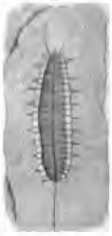

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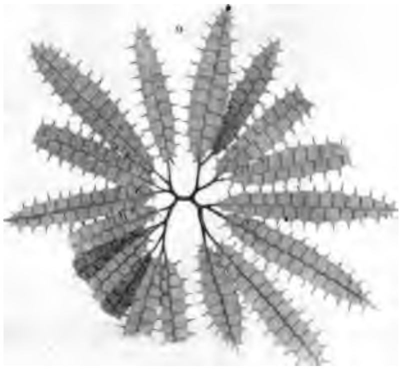

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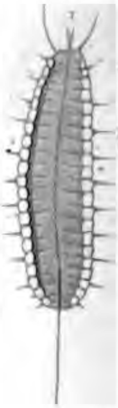

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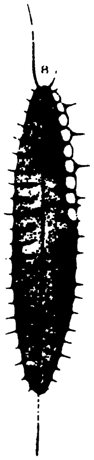

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James Hall, [illegible]

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EXPLANATIONS OF PLATE XV.

PHYLLOGRAPTUS TYPUS, page 119.

Fig. 1. An extremely short and broad form of this species, with the axis broad, and showing some remains of the cellules at the base of the separated division.

" 2. An elongate-ovate form of stipe, with a broad axis, which does not show remains of cellules. Some of the cellules in the upper part of the stipe are filled with iron pyrites.

" 3. A form similar to the preceding, showing remains of cellules on the upper part of the axis.

" 4. An elliptical form of stipe, where two of the divisions have been separated leaving the bases of two sets of cellules.

" 5. A broadly elliptical form, from which two of the divisions and the axis have been removed; showing the bases of the cellules of the folia which remain in the slate.

" 6. A stipe compressed in the same direction as fig. 3 of the generic illustrations page 119 ; with a part of one of the folia removed, but not reaching to the axis. The lines of the cell-partitions appear as if continued across the axis.

" 7. An elongate-lanceolate form of stipe, which does not show cellules in the line of the axis.

" 8. An elongate-elliptical and very symmetrical specimen, showing the marks of cellules along the axis, which is unusually narrow.

" 9. A part of a stipe folded in the manner of fig. 6, the upper portion of one side preserving only the impression of the substance. In the lower part, the cell-markings on the axis should be shown more distinctly.

" 10. A group of small stipes upon the surface of a piece of shale. These are given in their natural size and in their actual relations to each other.

" 11. An enlargement of a part of an impression of a stipe which has been flattened in the direction of figs. 6 and 9. A portion of the substance remains, as shown on the left hand; the cellules filled with iron pyrites.

" 12. An enlarged portion from a stipe, showing the double cell-denticles and corresponding cell-partitions. The narrow spaces on the surface of the figure are more elevated than the wider ones, with a greater thickness of the substance; which I suppose may have been caused by the cell-partitions, which are obliquely compressed, thus showing the cell-denticles. These elevated spaces become gradually narrower towards the axis, in accordance with the form of the cells, as shown in the theoretical figure 10 plate xvi.

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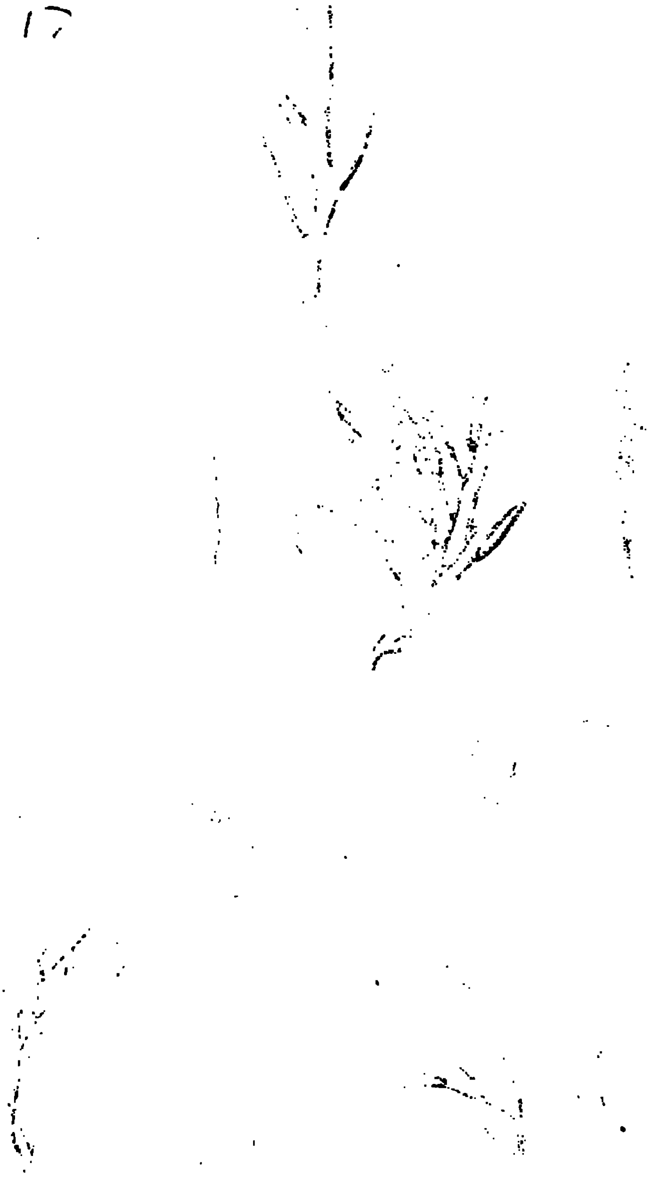

EXPLANATIONS OF PLATE XV.

PHYLLOGRAPTUS TYPUS, page 112.

Fig. 1. An extremely short and broad form of this species, with the axis broad, and showing some remains of the cellules at the base of the separated division.

" 2. An elongate-ovate form of stipe, with a broad axis, which does not show remains of cellules. Some of the cellules in the upper part of the stipe are filled with iron pyrites.

" 3. A form similar to the preceding, showing remains of cellules on the upper part of the axis.

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" 6. A stipe compressed in the same direction as fig. 3 of the generic illustrations (page 112); with a part of one of the folia removed, but not reaching to the axis. The lines of the cell-partitions appear as if continued across the axis.

" 7. An elongate-lanceolate form of stipe, which does not show cellules in the line of the axis.

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" 9. A part of a stipe folded in the manner of fig. 6, the upper portion of one side [illegible] substance [illegible] the lower part [illegible] shows more [illegible]

[illegible] of a stipe which has been [illegible] A portion of the substance remains [illegible]

[illegible] the double cellules [illegible] The narrow spaces [illegible] greater [illegible] been caused [illegible] which are obliquely compressed, thus causing the cell-apertures [illegible] spaces become gradually narrower towards the axis [illegible] the form of the cells, as shown in the theoretical figure [illegible]

Geological Survey of Canada.

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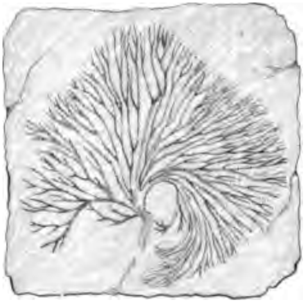

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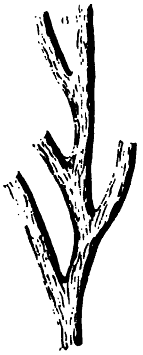

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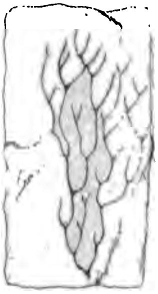

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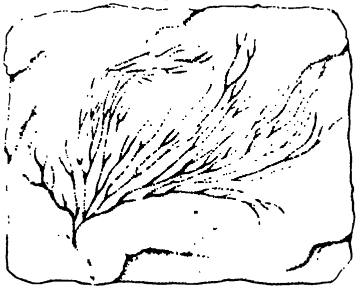

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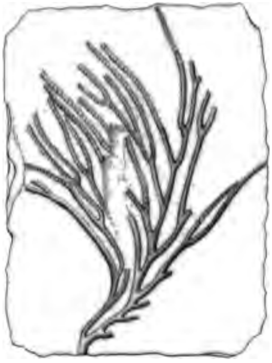

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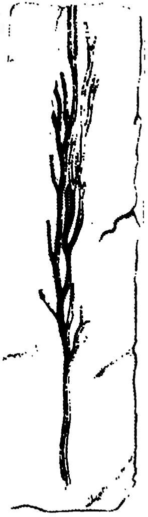

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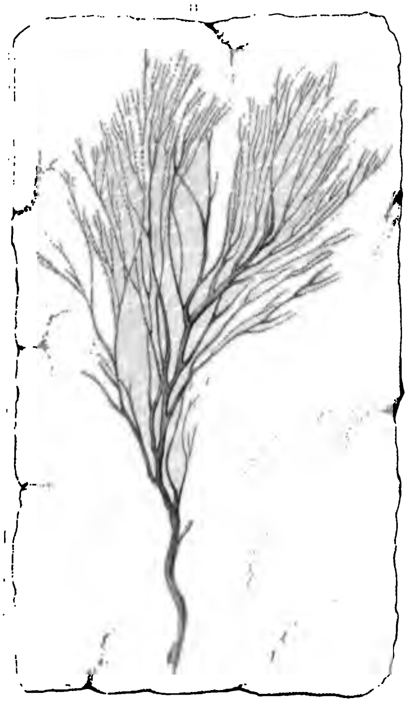

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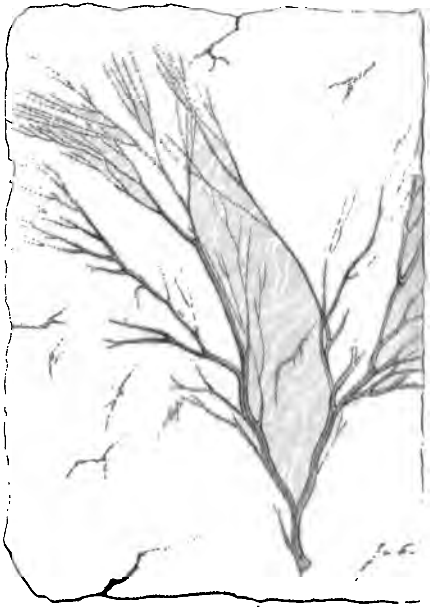

EXPLANATIONS OF PLATE XVIII.

DENDROGRAPTUS? (CALLOGRAPTUS?) DIFFUSUS, page 132.

Fig. 1 A portion of a broken frond from near the base. The test is removed in some parts, showing celluliferous markings.

" 2. A fragment of another specimen with similar cell-markings.

" 3. An enlargement, showing the cell-apertures. The specimens are extremely compressed.

CALLOGRAPTUS ELEGANS, page 134.

Fig. 4. A fragment which is more lax and spreading, with shorter branchlets than the ordinary specimens, but having similar striæ, and a similar arrangement of cellules.

DENDROGRAPTUS GRACILIS, page 132.

Fig. 5. Two of the larger branches with their sub-divisions, of the natural size.

' 6. An enlargement from one of the branchlets, showing the striate surface and the deep indentation of the cellules.

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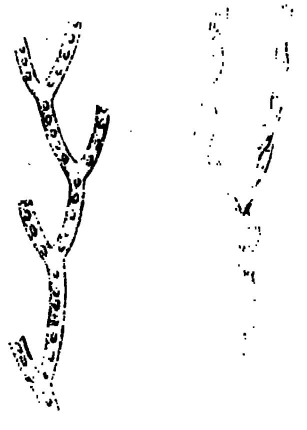

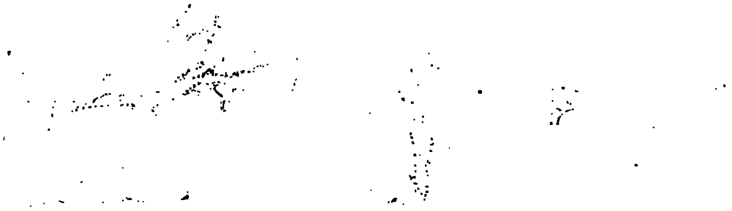

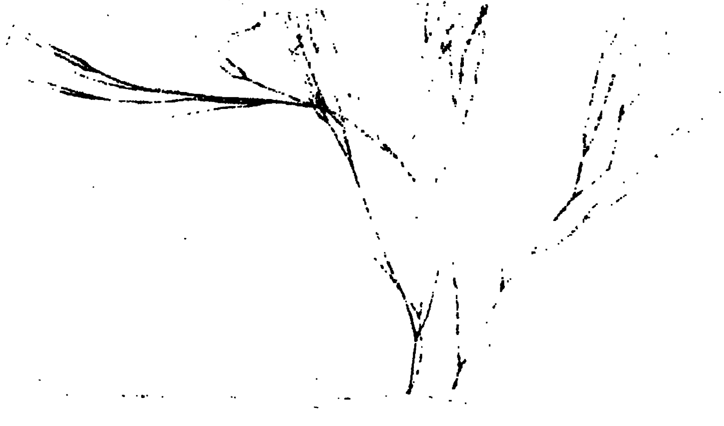

EXPLANATIONS OF PLATE XVIII.

DENDROGRAPTUS? (CALLOGRAPTUS?) DIFFUSUS, page 132.

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" 3. An enlargement, showing the cell-apertures. The specimens are extremely compressed.

CALLOGRAPTUS ELEGANS, page 134.

Fig. 4. A fragment which is more lax and spreading, with shorter branchlets than the ordinary specimens, but having similar striæ, and a similar arrangement of cellules.

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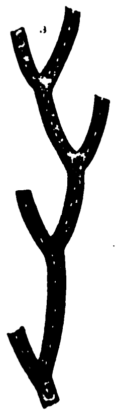
Graptolitidae.



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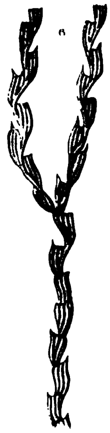

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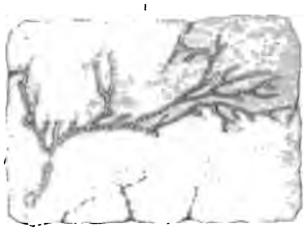

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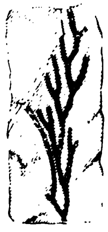

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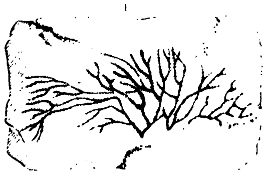

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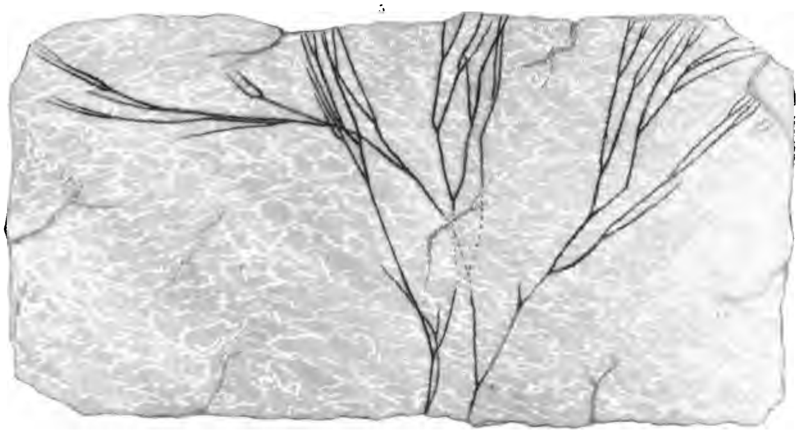

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EXPLANATIONS OF PLATE XIX.

CALLOGRAPTUS ELEGANS, page 134.

Fig. 1. A fragment of a frond, natural size.

" 2. A nearly entire flabelliform frond. The two shaded lines running nearly vertically through the figure, are due to faults or slips in the slate, causing a slight overlapping of the laminæ, and an interruption of the continuity of the frond.

" 3. An enlargement, showing the lateral connection of the branches at irregular intervals.

" 4. A further enlargement of the non-celluliferous side of a bifurcating branchlet, showing the striated surface and a semi-articulate structure.

CALLOGRAPTUS SALTERI, page 135.

Figs. 5, 6. Fragments of two distinct fronds; one showing the celluliferous side, and the other the non-celluliferous side.

" 7. An enlargement from the non-celluliferous side, showing a few transverse dissepiments at irregular intervals. The figure has the same degree of enlargement as fig. 3 of *C. elegans*.

" 8. A farther enlargement of a bifurcating branchlet, showing the cell-apertures.

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Sir W. E. Logan Director

Graptolitidae

Decade 2
Lower Silurian

Plate [illegible]
Quebec Group

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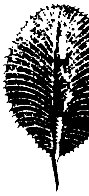

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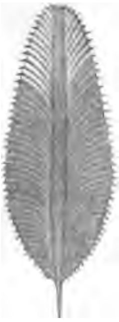

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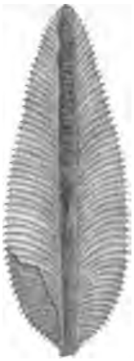

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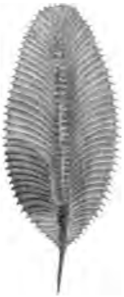

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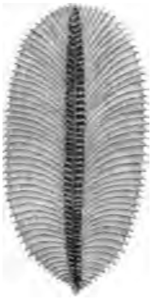

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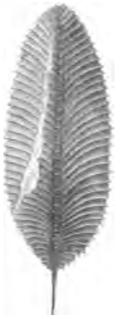

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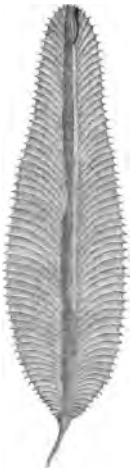

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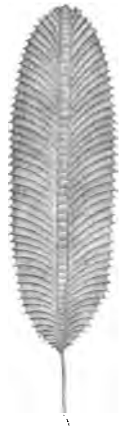

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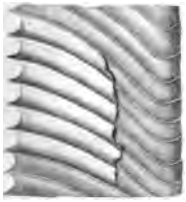

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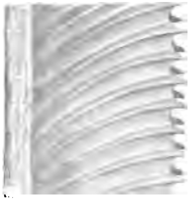

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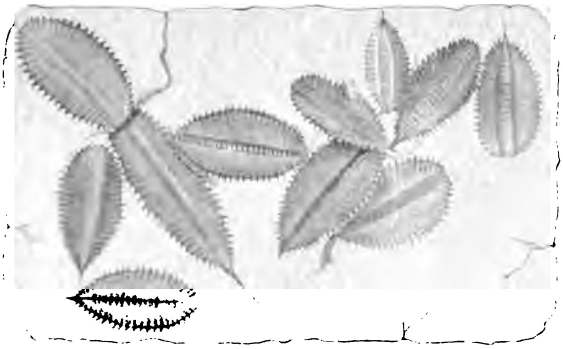

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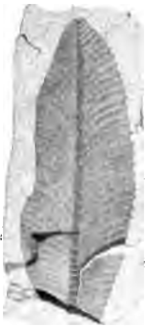

EXPLANATIONS OF PLATE XVI.

PHYLLOGRAPTUS ILICIFOLIUS, page 121.

Fig. 1. An individual of the natural size, where the folia *b*, *a*[*] are broken entirely away beyond the axis, leaving the bases of the cellules of two adjacent folia visible, except at the upper part of the figure, where two or three of the bases of the other cellules remain.

" 2. A similar specimen, showing the bases of a set of cellules on each side of the centre, with two or three of those belonging to the broken folium at the base of the figure.

" 3. An enlargement of fig. 2, showing more distinctly the cellules on each side of the central line, and the small remaining portion at the base.

" 4. A specimen of the natural size, where one folium is broken away not quite so far as the axis, leaving the bases of its cellules visible.

" 5. An enlarged figure from a specimen which has been imbedded transversely. Three of the divisions have been broken away, leaving impressions of the lateral ones only, and of the cell-bases and cell-partitions of the fourth division, which are directed obliquely upwards from the axis and point of view. The lower part of the specimen preserves a portion of the lateral folia, with the bases of the cells of the outer division *a*[*], which are directed towards the axis.

" 6. An enlargement of a specimen which is imbedded obliquely, or in a direction as if the theoretical figure 10 were vertically compressed, leaving no visible axis. In the lower half of the specimen, the fossil has been separated in the opposite slaty laminæ, leaving only the impression of that side, which also shows no axis. In the upper half of the specimen, the cellules are well preserved, and on the left-hand side the apertures are conspicuous. Enlarged to three diameters.

It will be observed that the impression is not quite in the same direction as the outline in the upper portion of the figure, owing to the obliquely-compressed folia.

" 7. A specimen compressed in the same manner as fig. 6; the upper folia have however been separated, except the bases of a few of the cellules in the upper part of the figure, leaving the other two folia imbedded in the shale, and showing the bases of their cellules ascending from the axis. Enlarged to three diameters, as in fig. 6.

" 8. An enlarged figure of a specimen compressed in the direction first described, without any separation of the parts; from which cause there is no proper axis visible. In this condition, the specimens resemble *Graptolithus folium* of Hisinger, or *G. ovatus* of Barrande.

" 9. An enlargement of a specimen compressed as in fig. 8, but with the cellules filled, and the margins of the upper two folia broken, showing the cell-openings. (8 and 9 are enlarged to twice their natural size.)

" 10. A restoration of the form of *P. ilicifolius*, showing the four divisions; which are represented as cut through transversely, exhibiting the cell-cavities.

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[*] These letters refer to the illustrative figures, page 119.

EXPLANATIONS OF PLATE XVI, continued.

PHYLLOGRAPTUS ANNA, page 124.

Fig. 11. A specimen with the folia obliquely compressed.

" 12, 13, 14. Individuals showing some varieties of form. The specimens have all been so imbedded that one of the folia has been torn away in the separated laminæ of shale, leaving an axis marked by the bases of its cellules.

" 15. An enlargement of a specimen which has one of the laminæ vertically imbedded, and shows the bases of the cells as they recede from the axis. The markings at the sides are from the impressions of the folia, except a small fragment of one remaining on the left-hand side of the figure.

" 16. An enlargement from a specimen where the two lateral folia remain, showing the bases of the cells of the folium which has been broken off, in the separated laminæ of slate. The surface is distinctly striated.

PHYLLOGRAPTUS ANGUSTIFOLIUS, page 125.

Fig. 17. A small and comparatively wide specimen, with a distinct linear axis, but without evidence of cellules.

" 18. A more elongate specimen, with distinct axis, with a darker line in the centre.

" 19, 20, 21. Varieties of form and proportion. The specimen fig. 21 is the largest observed.

This species is placed under *Phyllograptus* from its similarity in form to others of the genus, although evidence of the quadruple division has not been established. The want of parallelism of the margins, and the subelliptical form would, I conceive, be sufficient to remove it from the genus *Diplograptus*.

GRAPTOLITHUS BIGSBYI, page 86.

Figs. 22, 23, and 24 illustrate a common condition of this species, where two of the divisions show the lateral faces, while the non-celluliferous edge of a third division is seen lying nearly vertically in relation to these. The fourth division has been broken off in the separated film of slate.

" 25. A specimen showing the lateral faces of two divisions. Below these, in the shale, are seen the non-celluliferous edges of the two other divisions.

" 29 and 30 show a still closer arrangement of the parts, and the contiguity of the non-celluliferous edges at the apices, which are scarcely perceptibly separated in the shale.

" 26. An individual where the apices of the divisions are in contact, either conjoined, or accidentally so placed, with a narrow space in the centre. In obscure specimens it is difficult to separate such forms from *Phyllograptus*.

" 27. An individual where the divisions are equally spreading: one of them preserving only the base of the stipe.

" 28. The same enlarged.

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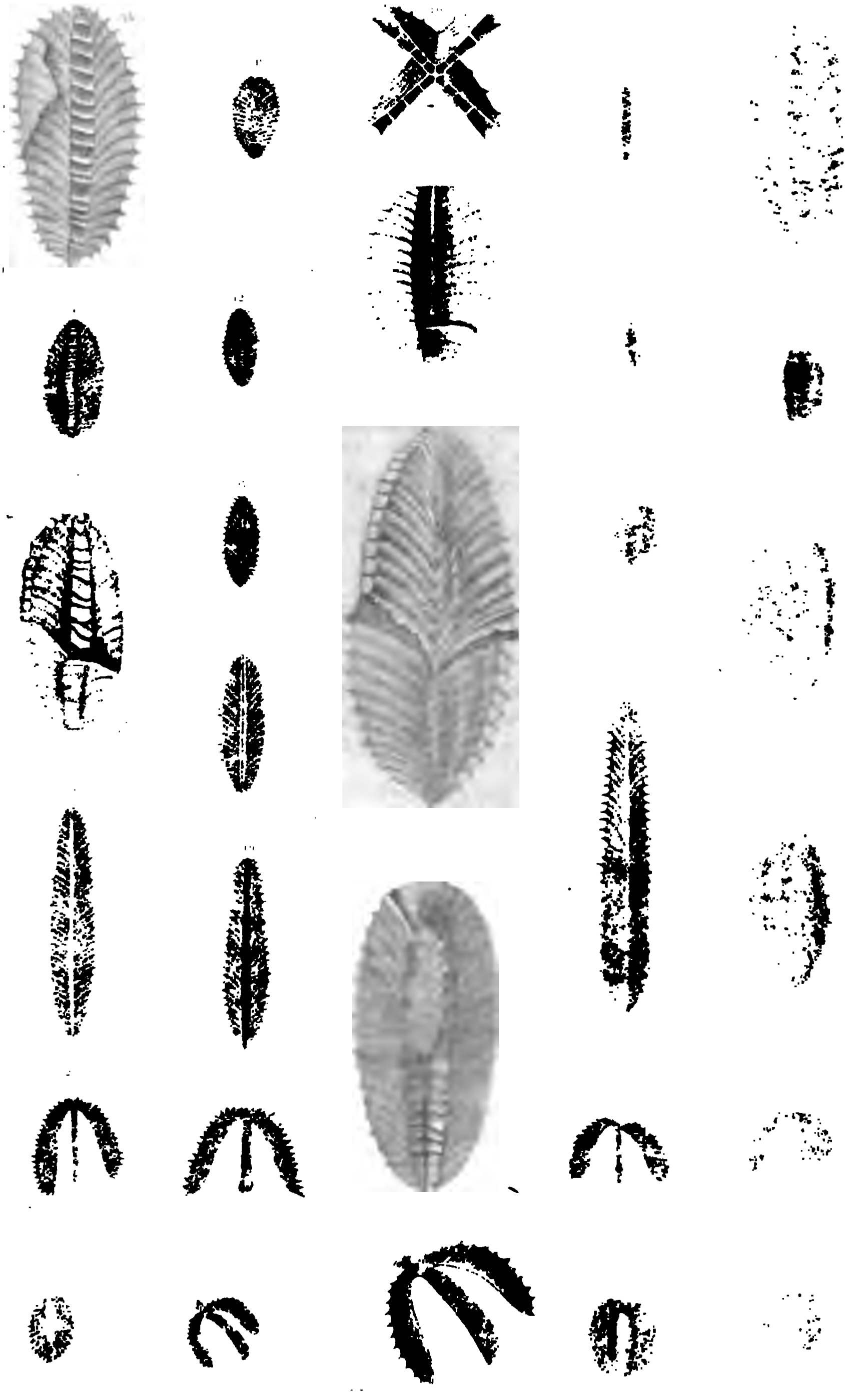

EXPLANATIONS OF PLATE XVI, continued.

PHYLLOGRAPTUS ANNA, page 124.

Fig. 11. A specimen with the folia obliquely compressed.

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G[illegible], page 86

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" 25. A specimen showing the lateral faces of two divisions. [illegible] in the [illegible], are seen the [illegible] celluliferous edges of the two other divisions.

" [illegible] close arrangement of the parts, and the [illegible] of [illegible] edges at the apices, which are scarcely [illegible] [illegible].

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" 27. An individual where the divisions are equally spreading; one of them preserving only the base of the stipe.

" 28. The same enlarged.

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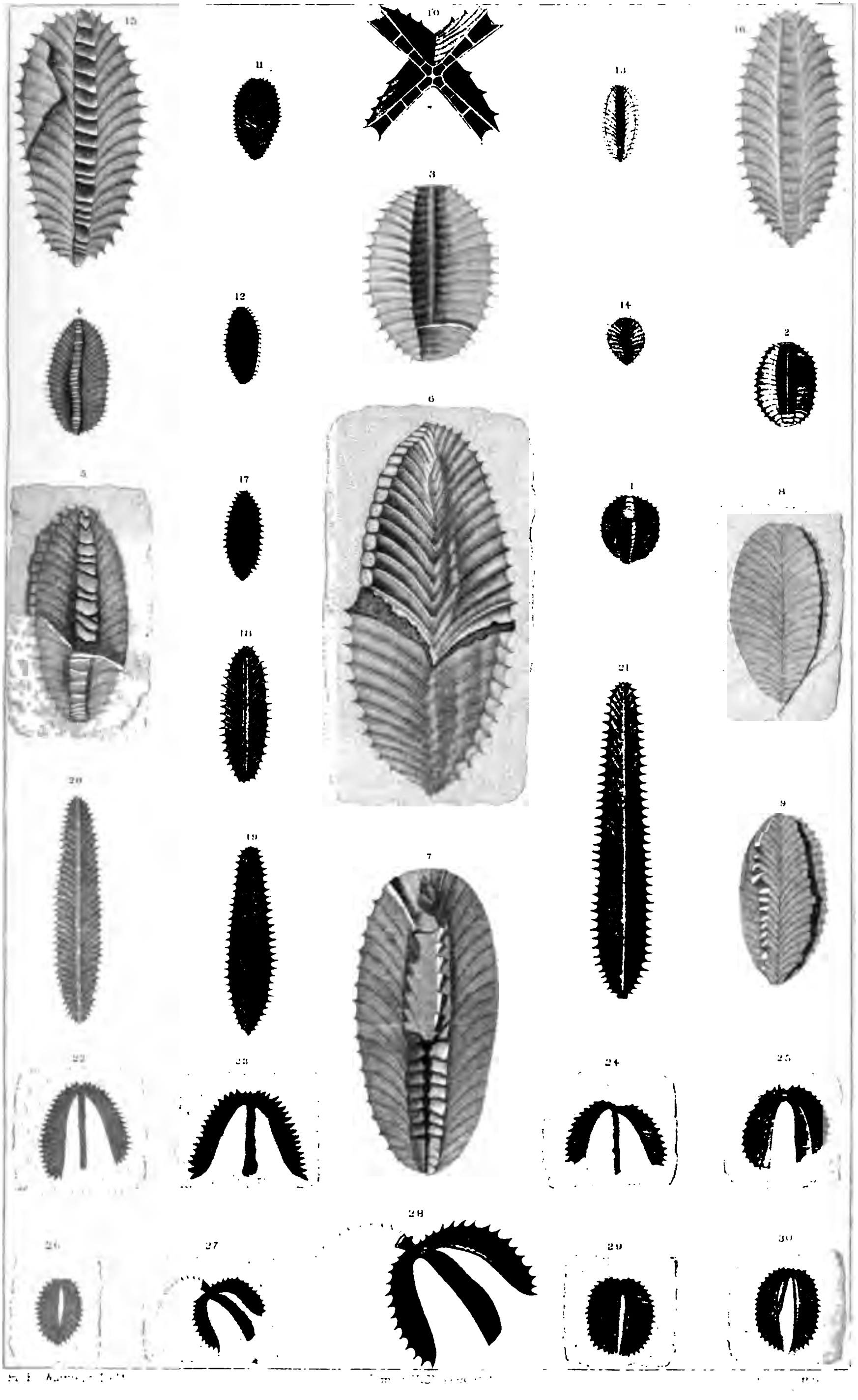

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EXPLANATIONS OF PLATE XVII.

DENDROGRAPTUS FLEXUOSUS, page 127.

Fig. 1. A small frond of the natural size.
2. A part of a larger frond.

DENDROGRAPTUS DIVERGENS, page 129.

Figs. 3, 4. A specimen of natural size, and an enlargement of the same.

DENDROGRAPTUS STRIATUS, page 129.

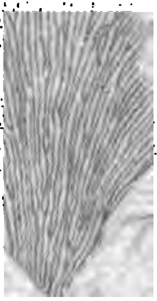
Fig. 5. A fragment of a frond, preserving the bases of some of the branches.
" 6. A portion of the non-celluliferous surface enlarged.

DENDROGRAPTUS ERECTUS, page 130.

Fig. 7. The principal stipe, and bases of some of the branches, of the natural size.

DENDROGRAPTUS FRUTICOSUS, page 131.

Fig. 8. A frond which is apparently nearly entire.
" 9. A more diffuse form of the same species, with some of the branches broken off.



EXPLANATIONS OF PLATE XVII

DENDROGRAPTUS FLEXUOSUS, page 127.

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2. A portion of a larger frond.

DENDROGRAPTUS DIVERGENS, page 129.

Figs. 3, 4. A specimen of natural size, and an enlargement of the same.

DENDROGRAPTUS STRIATUS, page 129.

Fig. 5. A fragment of a frond, preserving the bases of some of the branches.
" 6. A portion of the non-celluliferous surface enlarged.

DENDROGRAPTUS ERECTUS, page 130.

Fig. [illegible] stipe, and bases of some of the branches, of the natural size.

DENDROGRAPTUS FRUTICOSUS, page 131.

Fig. 8. [illegible] frond which is apparently nearly entire.
" 9. A more diffuse form of the same species, with some of the branches broken off.

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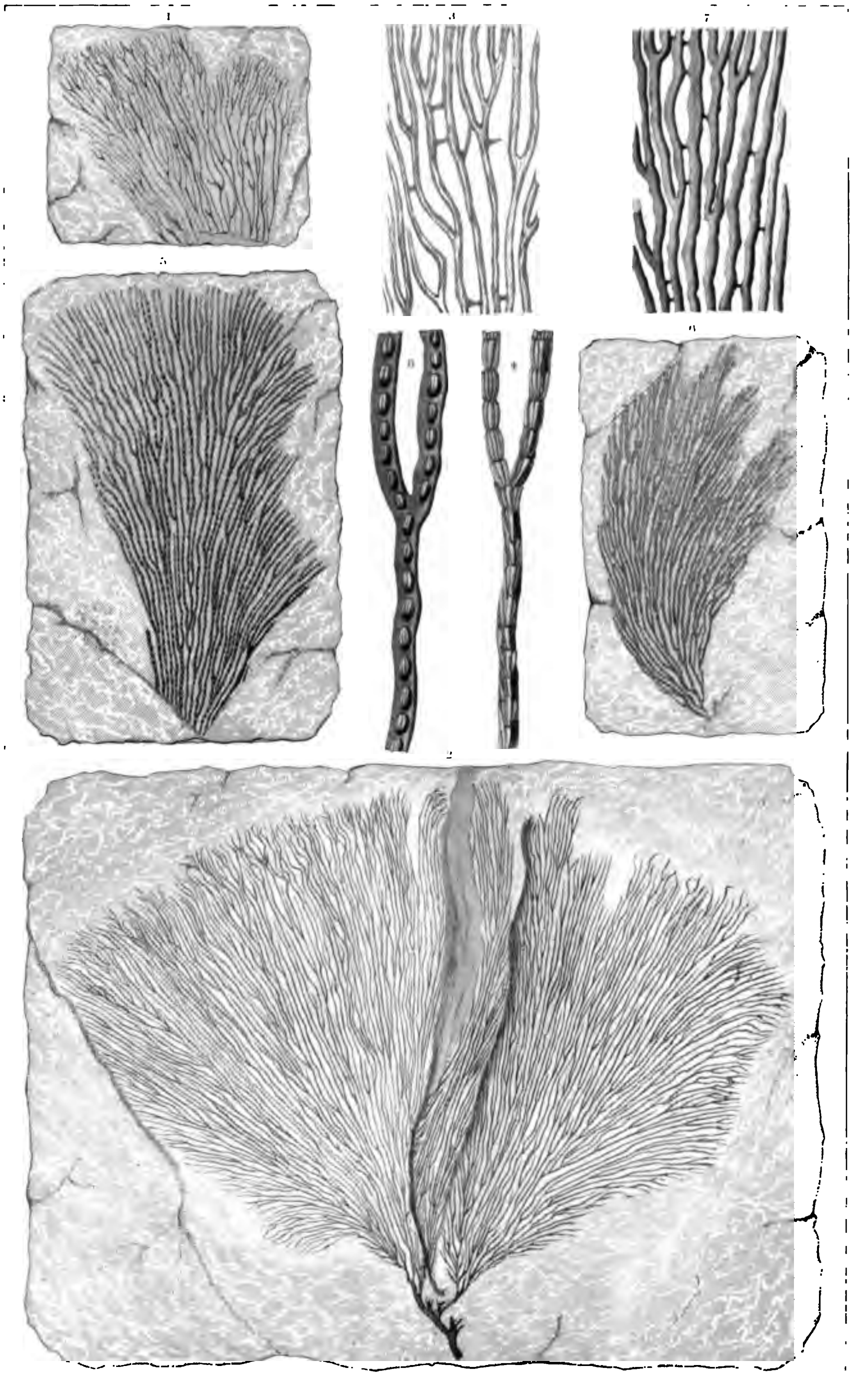

EXPLANATIONS OF PLATE XX.

DICTYONEMA IRREGULARIS, page 136.

Fig. 1. A fragment from near the base of a frond.
" 2. A fragment from the outer portion of the frond.

DICTYONEMA ROBUSTA, page 137.

Figs. 3, 4. Fragments of two different fronds. In some parts of the specimen fig. 3, and in all of fig. 4, the branches are extremely flattened and attenuate.

DICTYONEMA QUADRANGULARIS, page 138.

Fig. 5. A fragment of a frond, of the natural size.

DICTYONEMA MURRAYI, page 138.

Figs. 6, 7. Fragments of two fronds ; the figures of the natural size.

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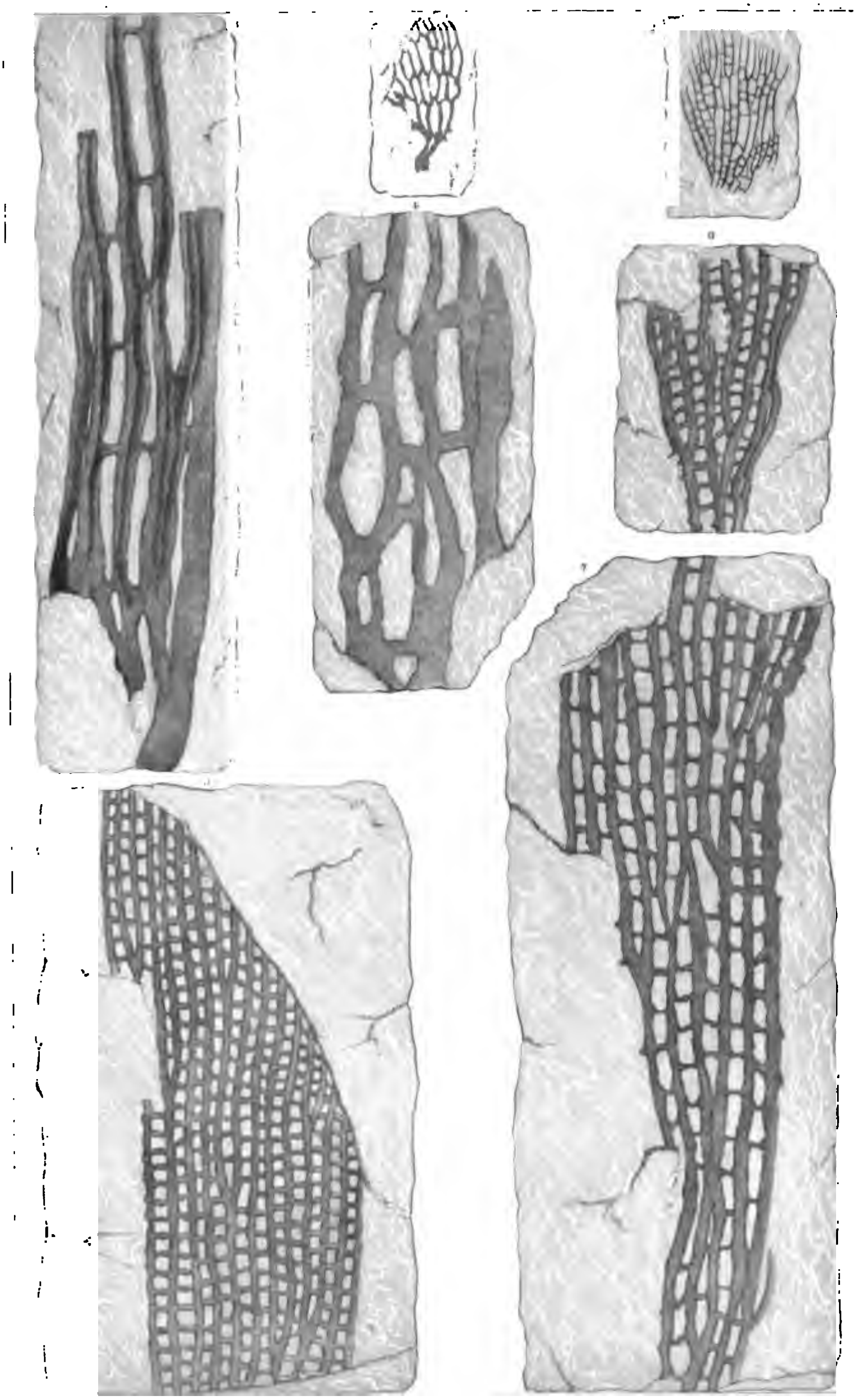

EXPLANATIONS OF PLATE XXI.

PTILOGRAPTUS PLUMOSUS, page 140.

Fig. 1. A fragment which is three times branched.
" 2. A slender simple branch.
" 3. An enlargement from the specimen fig. 1.
" 4. A further enlargement of a portion of the same; some of the branches showing markings like cell-apertures.

PTILOGRAPTUS GEINITZIANUS, page 140.

Fig. 5. A branching fragment showing the celluliferous side.
" 6. A fragment which is irregularly branched, showing the non-celluliferous side.
" 7. A single branchlet of the same species.
" 8. An enlargement from fig. 5, showing the cell-apertures.

THAMNOGRAPTUS ANNA, page 141.

Fig. 9. A fragment of the species, of the natural size.

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Canada 2.

Lower Silurian

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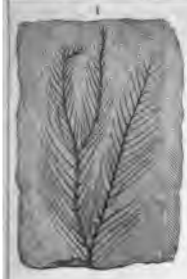

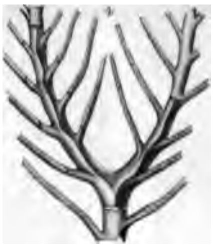

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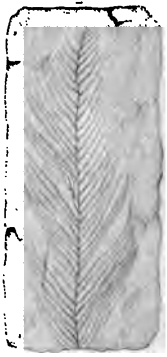

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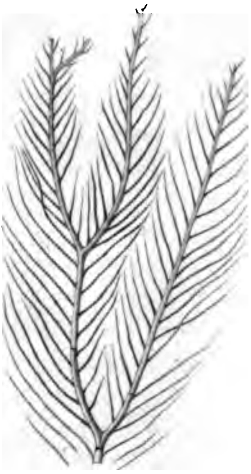

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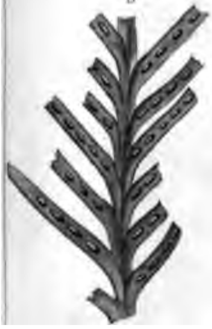

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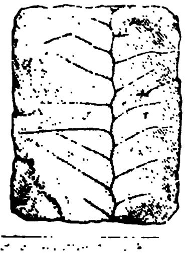

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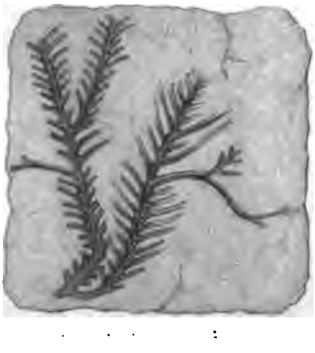

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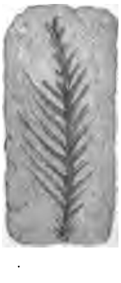

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